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Impact of Cluster Frontline Demonstrations on Yield of Chickpea (*Cicer arietinum* L.) in Prakasam District of Andhara Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Cluster Front Line Demonstrations (CFLDs) offer a unique approach to establish a direct interface between farmers and researchers, where the latter are involved in planning, executing, and monitoring the demonstrations. The objective of the current study was to evaluate the impact of front line demonstrations conducted for chickpea crop in the Prakasam district of Andhra Pradesh state. Chickpea (*Cicer arietinum* L.) is a highly nutritious legume crop that is widely recognized as both a health food and a high-return crop. The front line demonstrations were conducted at the

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farmers' fields to showcase the production potential and economic benefits of improved technologies. The findings revealed that the implementation of improved cultivation practices recommended under CFLDs, such as the use of recommended varieties, appropriate seed rate, timely sowing, and plant protection technology, resulted in a significant increase in gram crop yield compared to the check plots. The adoption of improved technologies led to higher yields, recording chickpea yields of 21.25, 21.75, and 19.50 q/ha during 2018-19, 2019-20, and 2020-21, respectively, which were 13.35%, 24.37%, and 22.22% higher than the prevailing farmer's practice. The average seed yield under improved practice (IP) was 20.83 q/ha, which was 15.48% higher than the farmer's practice (FP). The technology gap and extension gap ranged from 3.25 to 5.50 q/ha and 1.50 to 4.25 q/ha, respectively. The technology index value varied from 13.0% to 22.0% during the study period. The benefit-cost (B: C) ratio ranged from 2.23 to 2.84 under demonstration, while it was 2.15 to 2.57 under control plots. The average B: C ratio under IP (2.53) was 39.89% higher than that under FP.

Keywords: Frontline demonstration; chickpea; technology gap; extension gap; technology index.

1. INTRODUCTION

"Chickpea (*Cicer arietinum* L.) is the most widely cultivated edible legume in South Asia and globally, following common bean (*Phaseolus vulgaris* L.) and field pea. Cultivation of chickpeas is widespread across more than 50 countries, with the majority of the area in Asia (89.7%), followed by Africa (4.3%), Oceania (2.6%), the Americas (2.9%), and Europe (0.4%). The global production of chickpeas covers an area of 137 lakh hectares, producing 142.4 lakh tonnes and has a productivity of 1038 kg/ha" [1]. "Among the chickpea producing countries, India accounts for 70% of total bengalgram production, which amounts to 116.2 lakh tonnes and is grown over 112 lakh hectares, with a productivity of 1036 kg/hectare in the 2020-21 season" (agricoop.nic.in). Australia, Myanmar and Ethiopia are the next largest producers of bengalgram, after India [1]. "Bengalgram is the most important pulse crop in India, followed by Black gram, with Andhra Pradesh contributing 5.66 lakh tonnes from an area of 4.65 lakh hectares, having a productivity of 1218 kg/hectare in the 2020-21 season" (Third Advance Estimates, 2020-21, DES-AP).

The cultivation of chickpea has a positive impact on soil fertility due to its ability to fix atmospheric nitrogen, and it satisfies up to 80% of its nitrogen (N) requirements through symbiotic nitrogen fixation. By returning considerable amounts of residual nitrogen to the soil, chickpeas enhance the health and fertility of the soil. It is estimated that during one growing season, chickpeas can fix up to 140 kg of nitrogen. Chickpeas are mainly grown in semiarid and warm temperate regions, and are the most significant pulse crop during the rabi season. Apart from groundnuts and soybeans, chickpea has the highest protein yield and produces 126 kg of protein per hectare. "Additionally, chickpeas are highly nutritious, containing 24% protein, 59.6% carbohydrates, and 3.2% minerals" [2]. Due to their high nutritional value, chickpeas are considered a staple food in famine-prone regions. Besides their importance as a source of protein in the human diet, chickpeas play a significant role in biological nitrogen fixation in the soil. Notably, chickpea seeds provide 360 calories more energy per 100 g than any other legume, except groundnuts and lucerne.

"Meeting the increasing demand for pulses in India requires a significant increase in chickpea yield. However, most Indian farmers cultivate pulses on marginal land using indiscriminate chemical fertilizers, poor crop management techniques such as aggressive tillage and haphazard irrigation, and the absence of biofertilizers, which ultimately threaten the long-term viability of the crop. This has resulted in reduced soil fertility, limiting pulse crop production in low-input agricultural systems worldwide" (Lynch, 2007). Biofertilizers are an emerging environmentally sustainable fertilization method that falls under the category of organic fertilizers. Among the frequently used biofertilizers are Rhizobium and phosphate-solubilizing bacteria (PSB), which enhance various biochemical processes in soil, including nitrogen fixation, phosphorus solubilization and mobilization, zinc solubilization, and the generation of compounds that promote plant development and disease control. Utilizing biofertilizers is essential for increasing the sustainability of agriculture, as it provides a financially viable, visually attractive, and environmentally responsible method of fertilizing

[3]. Therefore, to maintain soil fertility and crop yield, it is imperative to identify environmentally friendly, practical, and affordable solutions to meet the nutrient requirements of rainfed chickpeas. To demonstrate and popularize improved agro-technology in various farming situations, Krishi Vigyan Kendra, Darsi, Prakasam district successfully organized cluster frontline demonstrations (CFLDs), aimed at increasing the productivity and farm gains of pulses through pulse intensification and diversification to sustain production systems.

2. MATERIALS AND METHODS

The Prakasam district in Andhra Pradesh has seen a decline in chickpea production due to farmers' reluctance to adopt improved production technologies. To address this issue, the Krishi Vigyan Kendra in Darsi conducted cluster frontline demonstrations (CFLDs) on chickpea cultivation in various villages of the district, including Lingam Gunta, Sudivaripalem, Korosapadu, Pothavaram, and Bollapalli during the rabi seasons of 2018-19, 2019-20, and 2020-21. A total of 25 farmers were selected for the CFLDs, covering an area of 10 hectares. The soil in the study area was clay loam in texture, slightly alkaline in reaction with a pH of 8.2, and had a low to medium fertility status.

Each CFLD was conducted with improved production components, including the use of the NBeG-49 variety, proper tillage, seed rate, line sowing using seed cum fertilizer drill, fertilization, seed treatment with chemical fungicide, dual inoculation of Rhizobium + PSB, soil application of Trichoderma, weed management, and protection measures. A control plot was included in each demonstration, where farmers used traditional practices. The crop was sown in mid-November under rainfed conditions, and a standard dose of 20 kg nitrogen and 50 kg P2O5 ha-1 was applied before sowing. Yield data was collected from both the demonstrations and the control plots using random crop cutting methods and analyzed.

The CFLDs were conducted to bridge the technology gap between farmers and available technologies. The study's significance is evident in the calculation of the technology gap, extension gap, and technological index [4], using the formulas (Eq. 1 to 4) provided below.

1. $\text{Percent increase yield} = \frac{\text{Demonstration yield} - \text{Farmers yieldx } 100}{\text{Farmers yield}}$
2. Technology gap = Potential yield – Demonstration yield
3. Extension gap = demonstration yield-farmer's practice yield
4. $\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield x } 100}{\text{Potential yield}}$

3. RESULTS AND DISCUSSION

3.1 Seed Yield

The farming community in Prakasam district has been positively influenced by the cluster front line demonstration, which showcased the application of new agricultural technologies. The results of the demonstration indicated that the CFLD practices, which included the use of improved varieties such as NBeG-49, balanced fertilization with N:P:K @ 20:50:0:20 kg NPKS ha-1, line sowing, timely weed management, and control of wilt and chickpea pod borer through fungicide and insecticide, resulted in an average chickpea yield of 21.25, 21.75, and 19.50 qha-1 during 2018-19, 2019-20, and 2020-21, respectively. This was 13.35%, 24.37%, and 22.22% higher than the yield obtained through prevailing farming practices (Table 2). The demonstration plot had an average seed yield of 20.80 q ha-1, which was 15.48% higher than the control plot's yield of 18.08 q ha-1. The highest increase in seed yield was observed in the demonstration plot during 2019-20 (27.37%), while the lowest was in 2018-19 (13.35%). These findings suggest that the CFLD practices have been impactful, motivating the farming community in Prakasam district with the new agricultural technologies used in the CFLD plots (Table 1). This conclusion aligns with the previous studies conducted by Tiwari et al. [5], Poonia and Pithia [6], and Raj et al. [7].

3.2 Technology Gap

Table 2 shows that the difference between actual yields and potential yields ranged from 3.25 to 5.50 q ha-1 in the demonstration, indicating a technology gap. This gap could be due to variations in soil fertility, salinity levels, erratic rainfall patterns, and other weather-related factors in the area. To address this, it may be necessary to provide specific recommendations for crop varieties based on location in order to minimize the technology gap and achieve optimal yields. Mitra et al. [8] reported similar findings.

Table 1. Comparison of demonstration packages and current procedures for chickpea CFLD's

S. No.	Chickpea		
	Particulars	**Demonstrationpackage**	**Farmerspractice**
1.	Farmingsituation	Rainfed	Rainfed
2.	Variety	NBe-49	JG-11
3.	Time of sowing	First week of November	First week of December
4.	Method of sowing	Line sowing	Line sowing
5.	Seedtreatment	Vitavax powder (Carboxin 37.5% + Thiram 37.5%) @ 2g/kg seed and *Trichodermaharzianum*@10 gm/kg seed	Not adopting
6.	Fertilizerdose	20:50:0 kg N:P:K ha-1 + Sulphur @ 20 kg/ha (N in form Urea and P inform of SSP)	Farmersareusing DAP only
7.	Biofertilizersapplication	Seed inoculation with Rhizobium 5 g and soil application of biofertilizer consortium @ 12.5 kg ha^{-1} at time of sowing	Not adopting
8.	Weed management	Pre-emergence application of Pendimethalin @ 1.5 lit ha^{-1} at 2 DAS	Manual weeding
9.	Plant protection	Needbasedapplication	Non judicious use of pesticides

Table 2. Seed yield, technology gap, extension gap, technology index and B: C ratio of chickpea under CFLD

Year	Seedyield (q/ha)			% increase over control	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)	B:C ratio	
	Potential	**Demo**	**Control**					**Demo**	**Check**
2018-19	25.0	21.25	18.75	11.76	3.75	2.50	15.00	2.52	1.78
2019-20	25.0	21.75	17.50	19.54	3.25	4.25	13.00	2.84	1.62
2020-21	25.0	19.50	18.00	7.69	5.50	1.50	22.00	2.23	2.01
Mean	25.0	20.83	18.08	12.99	4.17	2.75	16.68	2.53	1.80

3.3 Extension Gap

During the demonstration period, the extension gaps observed ranged from 1.50 to 4.25 qha-1, highlighting the importance of educating farmers through various channels to promote the adoption of improved agricultural production technologies and address the widening extension gap. By utilizing advanced production technologies and high-yielding varieties, farmers can potentially reverse this trend of increasing extension gaps. The adoption of new technologies will eventually encourage farmers to abandon old practices and embrace modern methods (refer to Table 1). These findings are consistent with the research conducted by Hiremath and Nagaraju in [9].

3.4 Technology Index

According to Jeengar et al. [10], "the technology index provides an indication of the viability of advanced technology in farmers' fields, and a lower technology index value indicates greater feasibility". Table 2 reveals that the average technology index was 16.68%, with a maximum technology index of 22.00% observed during 2018-19 and a minimum of 13.0% during 2019-20 [11].

3.5 B: C Ratio

The results of the study suggest that using CFLDS can have a positive impact on chickpea yields compared to traditional farming practices. The benefit-cost ratio was consistently higher for the demonstration group compared to the control group throughout the study period. Specifically, the average benefit-cost ratio for the demonstration group (2.53) was found to be 15.48% higher than for the farmer's practices.

4. CONCLUSION

The results obtained from frontline demonstrations indicate that utilizing improved technologies in Prakasam district can increase chickpea yields by 13.35 to 24.37%. The higher benefit-cost ratio confirms the economic feasibility of the demonstrations and the adoption of improved technologies by farmers. Furthermore, these demonstrations foster a positive relationship between farmers and scientists, building trust and confidence. Participating farmers in CFLDs serve as a valuable source of information and improved seeds for the wider dissemination of improved chickpea varieties to adjacent farming communities. The utilization of improved technologies is crucial to achieving higher chickpea and crop yields. Additionally, this approach facilitates the dissemination of other technical information by extension agencies to benefit farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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