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Short Communication

Enhancing the productivity of chickpea (*Cicer arietinum* L.) through integrated crop management practices

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ABSTRACT

The present study presented the impact of 155 demonstrations of improved chickpea technologies covering an area of 55.0 ha. The implementation of improved varieties and agricultural practices elevated the demonstration yield by up to 33.3% when contrasted with traditional farmer methods. During these three years of demonstrations, an average extension gap of 5.3 q/ha was recorded, highlighting the need to educate farmers through various extension methods. The demonstration plots yielded an additional net return of Rs. 28,450 in 2019-20, Rs 28,225 in 2020-21, and Rs. 29,600 in 2021-22. The adoption of improved technology resulted in higher benefit-cost ratios of 2.98, 3.03 and 3.14 compared to 2.27, 2.34 and 2.40 under local checks in the corresponding seasons of 2019-20, 2020-21 and 2021-22, respectively. The findings clearly demonstrate that CFLDs had a positive impact on boosting chickpea yield as compared to the existing practices in the region.

Key words: Benefit-cost ratio, Chickpea, CFLD, Extension gap, Extension methods, Net return.

Chickpea (*Cicer arietinum*) stands out as the predominant pulse crop, contributing to approximately 49% of the total pulse production in India. It is the second most important pulse crop after pigeon pea in the world for the human diet and other uses. It accounts for about 50% of Indian pulse production. Chickpea belongs to the Fabaceae family, and it is specifically a subclass of pulses. In northern India, they are often called gram and sometimes referred to as Egyptian or Kabuli chana. Chickpea acts as the primary source of dietary protein for around 20% of the global population (Hayat *et al*. 2010). Among pulses, it is the most important *Rabi* pulse crop of India, primarily cultivated in northern India. In the 2021-22 period, India's chickpea production amounted to 13.75 mt from a cultivation area of 10.91 m ha, yielding a productivity of 12.6 quintals per hectare (DES 2023, MoAF&W, GoI). It is primarily cultivated as a rain-fed crop, relying on stored soil moisture from the preceding monsoon (Singh *et al*. 2011). To achieve self-sufficiency, the projected pulse requirement in the country is estimated to reach 39 million tonnes by the year 2050, demanding an annual growth rate of 2.14%.

To achieve this target, it is very necessary to adopt the integrated crop management technologies to improve crop productivity. Therefore, it is of utmost importance to demonstrate the enhanced production technology and practices for chickpea directly on farmers' fields, enabling them to benefit from these advancements (Raj *et al.* 2013). The Indian Council of Agricultural Research (ICAR) in New Delhi introduced Cluster Frontline Demonstrations (CFLDs) in 2015 with the launch of the technology mission for pulse and oilseed crops. The Cluster Frontline Demonstrations were conducted under the supervision of KVK scientists in Unnao district of Uttar Pradesh, India. The main objective of the demonstration was to showcase high-yielding varieties with balanced nutrient management, focused plant protection technologies and improved management practices to enhance the productivity and area of pulses and encourage neighboring farmers to adopt these technologies under pulse cultivation with minimal inputs.

The study was conducted by Krishi Vigyan Kendra, Dhaura, Unnao in Unnao district of Uttar Pradesh, located at coordinates 26.5761°N, 80.5438°E, throughout the Rabi season of three consecutive years. Cluster Frontline Demonstrations were conducted over the *Rabi* season of 2019-2020, 2020-2021, and 2021-2022, focusing on chickpea cultivation using GNG-1581 and GNG-2144 varieties. During the 2019-20 period, 30 demonstrations were conducted, covering a total area of 10 hectares, using the GNG-1581 variety. In the subsequent years 2020-21 and 2021-22, a total of 125 demonstrations were conducted covering an area of 45 hectares utilizing the GNG-2144 variety of chickpea.

Farmers were chosen based on their active involvement, feedback, and cooperation during interactive meetings, discussions and training sessions conducted regarding different facets of cultivation (Venkattakumar *et al*. 2010). Soil samples were collected from the demonstration field of selected farmers' plots to analyze the soil and provide appropriate fertilizer recommendations.

The essential technologies for the demonstrations, as listed in Table 1 were provided to the farmers after their training. These include improved high-yielding varieties recommended bio-formulations, agrochemicals, literature, as well as regular visits, monitoring, and management of pests, diseases, advisory services and technical support by KVK scientists for the demonstration farmers. A field day was ultimately organized, engaging demonstration, holding farmers, other villagers, Scientists, agriculture department officials and local extension functionaries. The primary goal of the event was to highlight the advantages of the demonstrated technology. The farmers' practice was designated as the control field/local check, maintained according to their traditional cultivation practices. To identify the yield gaps between farmers' practices and frontline demonstrations, basic information was collected from the farmers' fields and analyzed to compare the performance of Cluster Frontline Demonstrations (CFLDs) with farmers' practices. Data on the listed parameters of both demonstration fields and control fields were collected at fixed intervals until crop harvest to assess the overall performance of the demonstration. The information regarding adoption pattern, replacement of variety and diffusion of technology in nearby villages was also recorded for the CFLD and other farmers.

After the collection of data from demonstration and control field technology gap, extension gap, additional return, technology index, and benefit-cost ratio were calculated by the formula adopted by Samui *et al*. (2000).

Technology Gap = Potential yield-Demonstration yield

Extension Gap = Demonstrated yield-Farmers' practice yield

Additional Return = Demonstration return – Farmers Practice return

$$\text{Technology Index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

Benefit : Cost Ratio = Gross Return/Gross Cost

Data outputs were collected from both CFLD fields and control fields and calculated for different parameters.

All three years of data of the chickpea crop were analyzed under CFLD and farmers' practice (control). The Tables 2 and 3 showcase the evaluation of chickpea crop grain yield over a span of three years, attributing the increase to the integration of enhanced technologies. Results for each year are delineated in Tables 2 and 3. The data reveal that the average grain yield of chickpea across all three years in demonstration fields exceeded that of farmers' practices. A complete disparity was noted concerning the utilization of high-yielding variety sowing methods, seed treatment, fertilizer dosage, and plant protection measures, thus impeding the attainment of optimum yield. Farmers typically opt for local or outdated varieties instead of embracing the recommended high-yielding, resistant varieties, often due to limited awareness and availability. The implementation of enhanced varieties and agricultural practices elevated the demonstration yield by up to 33.3% when contrasted with traditional farmer methods. Singh (1992) also documented that the adoption of improved varieties led to a 35% enhancement in productivity in contrast to local varieties of chickpea. Farmers employed the broadcast method of sowing instead of the recommended line sowing, leading them to apply a higher seed rate. This practice results in an increased number of plants, leading to heightened competition for sunlight and other resources. Through line sowing, we can maintain the appropriate number of plants, which affects our productivity. In the chickpea cropa 12% increase in yield was reported by Ali (2005) through line sowing as compared to broadcast. Weed infestation is very crucial to optimize crop productivity because it competes with various resources and reduces the yield. In the CFLD demonstration pre pre-emergence weedicide was recommended to get rid of the weed problem. Chopra (2001) reported that in the chickpea crop, the pre-emergence application of the herbicide

Table 1. Details of packages of practices under chickpea cluster front-line demonstration and farmer practices

S. No.	Technology Component	CFLD	Farmer's Practice
1	Improved variety	'GNG-1581' & 'GNG-2144'	Local
2	Soil treatment	with 5 kg/ha Trichoderma	No soil treatment
3	Use of Fertilizer dose	Soil test recommendation basis	unbalanced use of fertilizer
4	Seed treatment with fungicide	2 g Thiram + 1 g Carbendazim per kg seed	Seed not treated
5	Seed inoculum	with *Rhizobium*	No use of inoculum
6	Sowing method	Line Sowing	Broadcasting
7	Weed management	Use of Pre- emergence herbicide	
8	Irrigation	One or two need based irrigation	Usually excessive irrigation
9	Spray of 2 % urea	at flowering stage (70 DAS) and 10 days thereafter	No use
10	Insect Pest & disease management	use of IPM & IDM technologies need base	Overdose & use of non specific chemicals

Table 2. Yield analysis data for different indices

Year	Average Productivity (q/ha)			% increase over FP	Extension gap (q/ha)	Technology gap (q/ha)	Technology Index (%)
	Potential	CFLD	FP				
2019-20	24.0	22.5	17.1	31.2	5.4	1.5	6.25
2020-21	23.0	21.6	16.2	33.3	5.4	1.4	6.09
2021-22	23.0	22.0	16.8	30.9	5.2	1.0	4.35

Table 3: Economics of CFLD over farmers practice

Year	Gross return (Rs/ha)		Gross Cost (Rs/ha)		Net Return (Rs/ha)		Addition gain from CFLD (Rs/ha)	Benefit Cost Ratio	
	CFLD	FP	CFLD	FP	CFLD	FP		CFLD	FP
2019-20	101250	69300	34000	30500	67250	38800	28450	2.98	2.27
2020-21	104760	73235	34500	31200	70260	42035	28225	3.03	2.34
2021-22	113200	81600	36000	34000	77200	47600	29600	3.14	2.40

effectively controlled weeds and led to a 15% increase in yield. *Rhizobium* inoculation in pulses is essential to enhance production. Several researchers reported the significant impact of *Rhizobium* on different growth parameters of chickpea and other pulse crops (Khaitov *et al*. 2016, Shurigin *et al*. 2015, Egamberdieva *et al*. 2015). Before sowing seeds, the soil was treated with Trichoderma to protect the crop from various types of diseases.

Trichoderma spp. serves as a bio-control agent due to its efficacy against various soil-borne plant pathogenic fungi and its influence on specific root nematodes (Prasad *et al*. 2002, Naher *et al*. 2014). The results of different packages of practices are aligned with (Singh *et al*. 2017, Sharma and Singh 2024), the findings of other researchers, which highlighted the effectiveness of row planting compared to broadcasting in weed control, leading to a considerable boost in the productivity of the crop.

During the years 2019-20, 2020-21 and 2021-22, the extension gaps of 5.4, 5.4 and 5.2 q/ha respectively, were observed. The average extension gap over this period was 5.3 q/ha underscoring the necessity of educating farmers through various extension methods such as trainings, Cluster Frontline Demonstrations to encourage the adoption of improved production and protection technologies and reverse the widening extension gap trend. Increased utilization of the latest production technologies alongside high-yielding varieties will likely mitigate this concerning trend of widening extension gaps. The technology gap represented by the variance between potential yield and the yield of demonstration plots, amounted to 1.5 q/ha, 1.4 q/ha and 1.0 q/ha for the years 2019-20, 2020-21 and 2021-22, respectively. Over the three years, the average technology gap in the CFLD program was 5.39 q/ha. This technology gap could be attributed to disparities in soil fertility, agricultural techniques and local climatic conditions.

The technology index, ranging from 4.35 to 6.25 percent, signifies the fertility of demonstrated technology when implemented in farmers' fields. With an average technology index of 5.56 percent observed across the three years of CFLD programs, the effectiveness of successful technical interventions is underscored. This suggests a favorable trend towards the uptake of demonstrated technological interventions, potentially boosting chickpea yield performance.

To determine the economic viability of the improved/recommended technologies compared to traditional farmers' practices, various economic indicators such as cost of cultivation, net returns and benefit-cost ratio were calculated based on the prevailing market prices of inputs. Table 3 presents the economic findings from the frontline demonstrations on pulse crops conducted by KVK. It was found that the cost of production with improved technologies increased by up to 11.47% as compared to the farmer's practice. The additional cost incurred in the improved technologies was mainly due to the higher expenses associated with improved seeds, balanced fertilizers, IPM, IDM, and weed management practices.

Cultivation of chickpea using improved technologies yielded higher net returns, ranging from Rs. 77,200 to Rs. 67,250 per hectare. In comparison of traditional farmers' practices resulted in net returns ranging from Rs. 47,600 to Rs. 38,800 per hectare. The demonstration plots yielded an additional net return of Rs. 28,450 in 2019-20, Rs. 28,225 in 2020-21 and Rs. 29,600 in 2021-22. The adoption of improved technology resulted in higher benefit-cost ratios of 2.98, 3.03, and 3.14 compared to 2.27, 2.34 and 2.40 under local checks in the corresponding seasons of 2019-20, 2020-21 and 2021-22, respectively. The economic viability of the technology convinced the farmers of the utility of the interventions. The findings clearly demonstrated that CFLDs had a positive impact on boosting chickpea yield as compared to existing practices in the region.These findings align with the studies conducted by Narendra & Aaditya (2020), Dwivedi *et al*. (2014), Saikia *et al*. (2018) and Singh *et al*. (2020). The CFLD programs could be popularized among farmers for chickpea and other pulses to increase farmers' income and achieve self-sufficiency in pulse production in the region.

The results of CFLD study revealed that the improved varieties of chickpea with the intervention of different recommended technologies produced higher yields compared to traditional farming practices across all demonstrations conducted at different villages of Unnao district. The significant yield gap between research technologies and farmers' practices has led to lower productivity under traditional practices. The adaptation of improved technologies has to potential to significantly enhance productivity. Therefore, the extension agencies should motivate farmers to adopt the advanced innovations in order to minimize the yield gap. The CFLD programs can work as effective tools in improving the production of chickpea and other crops by replacing the improved varieties and changing the attitudes, skills and knowledge regarding modern agricultural practices.

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