



Increasing Chickpea (*Cicer arietinum* L.) Production through Frontline Demonstrations in Irrigated Regions of Central Punjab, 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

Aims: Frontline demonstrations plots are vital tools used by the government agricultural extension agents of India in bridging the gaps between research and extension for increase crop productivity. The study aimed at minimizing the extension-technology gaps for increasing the productivity of chickpea crop in India.

Study Design: Demonstrative design.

Methodology: Total 121 demonstrations plots were constructed over an area of 30 ha for a period of three years - 2017-2019.

Results: The result showed that average grain yield in the demonstration plot increased by 21.07% over the control fields. The mean technology gap and extension gap were 1.30 and 3.26 q ha⁻¹, respectively with 6.51% technology index value. The average benefit cost ratio for the demonstration plots was 3.55, compared to the control plot, which was 2.95.

Conclusion: It is concluded that the frontline demonstrations plots have a great potential to increase chickpea productivity in India. The demonstration techniques used can be adopted in diversifying crop production with improper irrigation facilities in order to increase food security in India.

Keywords: Chickpea; frontline demonstrations; extension gap; technology index.

1. INTRODUCTION

Chickpea or Bengal gram or gram (*Cicer arietinum L.*) is an important grain legume of the world which is grown in 44 countries across five continents. India accounts for 33 per cent of the world production of area and 22 per cent of the world production of pulses [1]. Besides helping in the management of soil fertility, particularly in the dryland, it is an important source of animal feed and human food. A large area of chickpea has been shifted to other crops in the country. With the increasing irrigation facilities in north India, the larger area of the region is replaced with other winter crops like wheat and mustard which resulted in the decline of area of chickpea from 3.2 m ha to 1.0 m ha in northern states. Stagnation in pulse production in India as compared to population increase rate of 1.44% has led to a steady reduction in per capita pulse availability [2]. Thus, there is a huge challenge for extension and agricultural scientists, government policy planners, and the farming community to sustain the pulse productivity as well its enhancement with main focus on narrowing the yield gaps, besides area expansion and diversified production systems well equipped with appropriate pulses production technology already generated by the research institutions, to break the yield plateau through appropriate technology transfer programs to harness recent technological advancements.

The steady decline of per capita availability of pulses is mainly due to the fluctuation in the production of pulses for the last 20 years [3, 4]. There are myriad of reasons for low yield of pulses as recommended time of sowing time is not followed due to non-availability of good quality high yielding seed. Moreover, the plant stand is generally higher at farmer's fields as compared to recommended stand. There is also loopholes in the machinery used for pulses production mainly low popularity of seed cum fertilizer drill for sowing along with the imbalance of nutrients with respect to dose and type of fertilizers like phosphatic fertilizers by farmers does not help in achieving the possible potential yield [5, 6]. The frontline demonstrations technology-transfer program (FLD-TTP) in pulses is conducted under the close guidance and supervision of extension and agricultural scientists. It is an initiative by the Ministry of Agriculture under the aegis of the government of

India and is a form of adaptive research. As the frontline demonstrations works on the principle of learning by doing and seeing is believing, it makes them the most efficient and effective tool for the extension programs. It provides a close analysis of production constraints in existing farm practices and performance of improved farm technology under varied farming situations, for rapid transfer of technology to enhance productivity and farm income besides diversifying production systems for pulse self-reliance [7]. The present investigation was undertaken to demonstrate and transfer the generated farm technology through frontline demonstrations in pulses under irrigated production systems with the objectives of increasing the productivity and profitability of farmers along with bridging the gaps in extension for pulse production system sustainability in Punjab.

2. MATERIALS AND METHODS

The present study was carried out in Krishi Vigyan Kendra (Jalandhar), Punjab Agricultural University during the *rabi* season for three years from 2017-18 to 2019-20 in the farmers field of 35 villages across the district of Jalandhar. All the 121 frontline demonstrations (FLDs) under the area of 30 ha were conducted across different villages under the supervision by following the recommended package of practices (Table 1). The area of study is located in central Punjab with a sub-tropical climate.

The trainings prior to sowing were organized for the selected farmers in the village. Initially, farmers were given training for successful cultivation of chickpea by providing literature to carry out demonstrations along with other inputs like the seed of recommended and new high yielding variety, followed by recommended pesticides with the aspect of management of diseases and insects. Regular visits and advisory by the KVK team were also ensured to the farmer's field. A field day was also conducted during the harvest to demonstrate the successful technology to motivate other farmers. Grain yields were recorded from the demonstration fields and control fields at the time of harvest. The soil samples were also taken and tested from the plots. The fertilizer application was recommended as per soil test report. The soils were medium in fertility and sandy loam texture mainly.

Table 1. Comparison between the packages of practices followed under the frontline demonstrations and by the farmers' for chickpea fields

Technology component	Frontline demonstrations	Farmer's practice	Technology gap
Improved variety	PBG 7	Local variety (Mixture)	Full
Seed rate	15-18 kg	20-25 kg	half
Time of sowing	25 October-10 November	1-30 November	Full
Method of sowing	Line sowing (30 cm) Bed sowing (67.5 cm)	Broadcast	half
Seed treatment	Recommended pesticide	None	Full
Use of biofertilizer	Mesorhizobium+ rhizobacterium	None	Full
Basal application of fertilizers	32.5 Kg Urea+ 125 kg SSP	Irrational use of Urea and no use of Sulphur	Full
Plant protection measures	Need-based spray of pesticides and use of resistant variety	Overdose and use of recommended pesticides	Full

The grain yield data was collected from the farmer's field through rom plot cutting method followed by the personal interaction with the demo farmers. The increase in yield in demonstration plot over the yield in farmers' plot was calculated according to the following formula:

% in yield increase over farmers' practice = $\frac{\text{Average yield from demonstration plot} - \text{average yield from farmers plot}}{\text{average yield from farmers plot}}$

2.1 Estimation of Technology Gap, Extension Gap, Technology Index

The estimation of technology gap, extension gap, technology index was calculated using following formula [8, 9]:

- i) Technology gap = $\frac{\text{Potential yield-Demonstration plot average yield}}{\text{Demonstration plot average yield}}$
- ii) Extension gap = $\frac{\text{Demonstration plot average yield} - \text{Farmer's plot average yield}}{\text{Farmer's plot average yield}}$
- iii) Technology Index = $\frac{\text{Pi}-\text{Di}}{\text{Pi}} \times 100$

Where Pi = Potential yield of i^{th} crop Di =Average demonstration plot yield of i^{th} crop.

2.2 Technologies Assessment

Ten plots were assessed for each recommended technology with a control plot. The following technologies were assessed at farmers' field along with the main demonstration plot:

- (i) Use of high yielding variety (PBG 7)
- (ii) Rhizobium inoculation

- (iii) Date of sowing of the crop: Late sowing with the recommended time of sowing
- (iv) Flat sowing of chickpea with bed sowing
- (v) Use of SSP or Sulphur with no application of Sulphur
- (vi) Irrigation assessment

2.3 Economic Analysis of Front Line Demonstrations

Cost of cultivation of chickpea includes cost of inputs required like seeds, recommended fertilizers, pesticides used by the farmers (in farmers' plots) /supplied by the Krishi Vigyan Kendra Jalandhar (in demonstration plots) as well as any hired labour, any cost of sowing by bullocks / tractor or any post-harvest operation charges. The farmers' family labour is excluded from the present study. The gross net-returns were calculated by taking the cost of cultivation price of grain yield of respective pulses into consideration. Likewise, the Benefit-Cost-Ratio (BCR) was calculated as a ratio of net returns to the corresponding costs of cultivation as per the procedure followed by Vedna et al. [10].

3. RESULTS AND DISCUSSION

3.1 Grain Yield

The data for the grain yield is presented in Tables 2 & 3. The data revealed that the accurate transfer of technology resulted in invariably higher yield under the demonstration plots (18.71 q ha⁻¹) than the farmers practice (15.45 q ha⁻¹) which may be due to the adoption of new recommended technologies by the farmers under the demonstration plots. On an

average, yield increased by 21.07% in the demonstration plots as compared to the control plots. The average yield in demonstration plots was 18.97, 19.2 and 17.95 q ha⁻¹ in the year 2017-18, 2018-19 and 2019-20, respectively with an increase of 22.1, 20.4 and 20.7 percent over the control plots. The lower yield in the year 2019-20 was due to the excessive rainfall throughout the season leading to higher vegetative growth which resulted in declining the yield. Although there was a decrease in average yield but the increase in yield over the control remains the same because the higher rainfall leads to yield reduction in both the demonstration and control plots. Singh et al. [11], Dwivedi et al. [12] Kumar et al. [13] and Sharma et al. [14] reported similar findings that there is an increase of yield with the adoption of recommended agro-technologies under frontline demonstrations. The increased yield of chickpea in demonstration plots was mainly due to new and recommended varieties along with the balanced use of nutrients and pesticides. Late or early sowing along with no control measures for pest and disease management of chickpea cultivation. Front Line demonstrations act as a bridge between scientists and farmers as the scientists are directly involved in planning, execution and monitoring of the demonstrations for the technologies developed by them. The

demonstrations attract low and medium package of practices which in turn increases its adoptability as the demonstration fields becomes higher profitable and higher remunerative. The enhancement of yield by adopting improved farm technology has also been reported in earlier studies [15, 16, 17, 13, 18, 5; 14].

3.2 Technology Gap

The findings of the study showed that the technology gap for chickpea was 1.04, 0.80 and 2.05 q ha⁻¹ during the year 2017-18, 2018-19 and 2019-20, respectively with an average value of 1.30 q ha⁻¹ over the three years (Table 3). The technology gap is always present even if the demonstrations are conducted under the direct supervision of scientists. This is generally due to the dissimilarity in the soil fertility status, irregular rainfall over the areas, location-specific crop management problems and weather conditions as well as the change in the locations of demonstration plots every year [19, 21, 7]. These reports emphasize that site specific crop management is required to minimize the gap in potential demonstration yields, alongside the strengthening of the irrigation facilities in the area [10]. The technology gap also reflects the farmer's co-operation to conduct the demonstrations with encouraging results.

Table 2. Grain yield analysis of frontline demonstrations on chickpea

Year	Variety	Number of trials conducted	Total area (ha)	Average Yield (q ha ⁻¹)	Minimum Yield (q ha ⁻¹)	Maximum yield (q ha ⁻¹)	Remarks
2017-18	PBG 7	25	10	18.97	11.2	20.9	Adequate rainfall
2018-19	PBG 7	54	10	19.20	11.5	21.5	Adequate rainfall
2019-20	PBG 7	42	10	17.95	10.9	20.4	Higher rainfall during the season causes lower yield

Table 3. Yield performance, yield gap and technological index analysis of chickpea under frontline demonstrations

Year	Average Yield (q ha ⁻¹)			Increase in yield (%) over local	Technology gap (q ha ⁻¹)	Extension gap (q ha ⁻¹)	Technology index (%)
	Potential	Demo	Local Check				
2017-18	20	18.97	15.54	22.1	1.04	3.43	5.15
2018-19	20	19.20	15.95	20.4	0.80	3.25	4.12
2019-20	20	17.95	14.86	20.7	2.05	3.09	10.25
Average		18.71	15.45	21.07	1.30	3.26	6.51

3.3 Extension Yield Gap

Extension yield gaps indicate the lack of awareness in the farmers for the adoption of new and improved technologies [16, 5,10]. The results indicated that the extension gap was 3.43, 3.25 and 3.09 q ha⁻¹ for the year 2017-18, 2018-19 and 2019-20, respectively with an average value of 3.26 q ha⁻¹ over the three years (Table 3). The successful development, its dissemination and adoption of new technologies for small landholders depends on more than careful planning of research and the use of appropriate methodologies in extension [21, 22]. To reduce the wide extension gap, the farmers have to be educated by various extension measures to adopt the improved technologies of agricultural production. The burgeoning of extension gap can be minimized by the adoption of new technologies along with the use of high yielding varieties. The higher profit of the new technologies will eventually discourage the reduction of the use of to reduce the use of old technologies and replace them with new technologies. These results confirm the findings of crop technology demonstration on oilseed and pulses crops by Lathwal [23] and Yadav et al. [24].

3.4 Technology Index

The technology index shows the feasibility of the improved technology at the farmer's fields and the lower the value of the technology index more is the feasibility of the technology [25]. Lower is the value of technology index, there are higher chances of the feasibility of generated farm technology under farmers' fields and vice-versa. Data in Table 3 revealed that the technology index was 5.15, 4.12 and 10.25% 1 for the year 2017-18, 2018-19 and 2019-20, respectively with an average value of 6.51% over the span of three years (Table 3). The higher value of the technology index during the year 2019-20 is mainly attributed due to the decline in grain yield caused by the excessive rainfall throughout the season as chickpea require less water. Secondly, higher attack of pod borer in chickpea, results in poor yields, could be the plausible reasons for lower crop cultivation among farmers responsible for higher technology index. The results suggest that the availability of high yield variety along with the site-specific agriculture technologies and wide awareness campaigns may lead to higher adoption of pulses among farmers. This finding is in line with the findings of

Hiremath and Nagaraju [26]; Vedna et al. [10] Vaghasia et al. [27]; Choudhary et al. [7].

3.4.1 Technologies assessment

Ten demonstrations were conducted each year for each aspect by following the recommended packages of practices excluding one aspect of recommended techniques. These demonstrations were conducted to show the effect of every single parameter in enhancing the yield of the crop. The results in terms of grain yield of every aspect are given in Table 4.

- (i) **Use of high yielding variety (HYV):** In demonstration plots, HYV PBG 7 was used as compared to local variety used for farmers. All the other recommended practices were followed. It can be seen from Table 4 that there is a 17.08% increase in yield as compared to the local variety used. This variety is not only high yielding but is also moderately resistant to *Ascochyta* blight and fairly resistant to wilt and dry root rot. These results emphasize the importance of using variety, therefore farmers should be encouraged to use only the recommended varieties.
- (ii) **Rhizobium inoculation:** The demonstration plots were treated with Mesorhizobium and rhizobacterium before sowing which causes a 4.79% increase in yield in demonstration plots (19.50 q ha⁻¹) as compared to control plots (18.61 q ha⁻¹). The use of biofertilizers is very important in the case of pulse crops as it enhances their nitrogen-fixing capability. Similar results were also reported by Poonia and Pithia [28] and Dudhade et al. [29] in chickpea.
- (iii) **Time of sowing:** The recommended time of sowing of chickpea under Punjab conditions is 25th October to 10th November. There is an increase of 7.56% in grain yield when the crop was sown during the recommended time (18.5 q ha⁻¹). The yield was 17.20 q ha⁻¹ when the crop was sown either 20 days earlier or late sown. This is mainly due to the wilt owing to high temperature in the early sown crop. In the case of late sown crop, the vegetative growth is poor with inadequate root development.
- (iv) **Bed sowing vs flat sowing:** In medium and heavy textured soils, the crop was sown on beds (spaced 67.5 cm apart) and flat sown. It was observed that there was

an increase of 5.16% grain yield in the case of bed sown crops as compared to flat sowing. This is mainly due to the fact that raised bed sowing saves the crop from an adverse effect of irrigation on heavy textured soils.

- (v) **Use of Sulphur:** When sulphur @ 20 kg/ha was used in the crop, there was an increase of 10.26% in grain yield as compared to control plots. These results were in line with those reported by George [30], Kala et al. [31] and Mohammad et al. [32].
- (vi) **Number of irrigations:** Chickpea is a rainfed crop and requires a smaller number of irrigations. When the crop was given only 2-3 irrigations, there was an increase in yield by 18.58% over the control where 6-7 irrigations were applied to the crop. This is mainly due to the enhanced vegetative growth which depresses the grain yield in case of a higher number of irrigations.
- (vii) **Spray of 2% urea:** There was an increase in grain yield by 7.12 % when the crop was sprayed with 2% urea solution 90 and 110 days of sowing as compared to control plots.

3.5 Economic Analysis of the Frontline Demonstrations

The inputs and outputs prices of commodities prevailed during the study of demonstrations were taken for calculating gross return, cost of cultivation, net return and benefit: cost ratio (Table 5). On an average under demonstration plots, the cost of cultivation was Rs 16986.7 per

hectare with gross returns of Rs 60355.7 per hectare and net profit of Rs 43369 per hectare over the span of three years from 2017-2019. On the other hand, under control plots, the cost of cultivation was Rs 15729.7 per hectare with gross returns of Rs 46458.3 per hectare and net profit of Rs 30728.7 per hectare over the span of three years from 2017-2019. The higher cost of cultivation is mainly due to the high seed cost of high yielding varieties. Therefore, an additional profit of Rs 12640.3 per hectare can be gained through the proper following of recommended package of practices.

The average benefit-cost ratio was higher under chickpea demonstration as compared to control plots during the years of the study (Table 4). The benefit-cost ratio of chickpea cultivation under improved cultivation practices were 3.54, 3.55 and 3.51 as compared to 2.97, 2.95, and 2.93 under farmer practices for the year 2017-18, 2018-19 and 2019-20, respectively. The high net returns and B: C ratio in chickpea demonstration plots is due to the high grain yield and fetching of the better selling price of the chickpea in the market. Hence, it clearly shows that the demonstration plots of chickpea with the full recommended package of practices were better than the farmer's practices. These results are consistent with the findings of Singh et al. [11]; Kumar [16]; Teggelli et al. [18]; Singh et al. [33]; Mokidue et al. [34]; Tomar [35]; Dhaka et al. [36]; Hiremath and Nagaraju [26]; Kirar et al. [37] and Gurumukhi and Mishra [38]. Thus, economic analysis data suggests that the successful transfer of new and improved technology and its adoption in pulses may increase the profitability substantially on farmer's field.

Table 4. Mean grain yield for the different recommended technologies assessed on chickpea

Technology Assessed	No. of FLDs (10 each year)	Grain yield (q ha ⁻¹)		% increase	Extension gap (q ha ⁻¹)
		Improved	control		
Use of high yielding variety (PBG 7)	30	18.85	16.10	17.08	2.75
Rhizobium inoculation	30	19.50	18.61	4.79	0.89
Time of sowing	30	18.50	17.20	7.56	1.3
bed sowing with Flat sowing	30	18.74	17.82	5.16	0.92
Use of Sulphur	30	19.02	17.25	10.26	1.77
No. of irrigations	30	19.27	16.25	18.58	3.02
Spray of 2% urea	30	19.84	18.52	7.12	1.32

Table 5. Economic performance of frontline demonstration plots and local check on chickpea

Year	Cost of cultivation (Rs. ha ⁻¹)		Gross returns (Rs. ha ⁻¹)		Net returns (Rs. ha ⁻¹)		Additional net returns over check (Rs. ha ⁻¹)	Benefit cost ratio	
	Demo	Local check	Demo	Local check	Demo	Local check		Demo	Local check
2017-18	16644	15545	59754	46245	43110	30700	12410	3.59	2.97
2018-19	17562	15966	62488	47120	44926	31154	13772	3.55	2.95
2019-20	16754	15678	58825	46010	42071	30332	11739	3.51	2.93
Average	16986.7	15729.7	60355.7	46458.3	43369	30728.7	12640.3	3.55	2.95

4. CONCLUSIONS

It can be concluded that the CFLD program is an efficient tool for enhancing the production and productivity of pulses as well as changing the knowledge, perception, skill of farmers. The poor marketing support, credit support and storage facilities act as distinctive to the growers. There is a wide gap in profitability and potential yield of chickpea production owing to technological gaps and extension gaps. The use of a scientific and improved method of chickpea cultivation can lower the technology gap to a greater extent which will lead to an increase in the productivity of chickpea. However, the extension workers need to provide proper technical guidance and support to the farmers through different educational and extension methods to reduce the extension gap for better chickpea production. Horizontal spread of improved technology may be attained by successfully conducting the frontline demonstrations and various extension activities in farmers yield. The study emphasizes the popularization of site-specific crop management with improved technologies imbedded with new high yielding varieties to increase and sustain the pulse productivity and its profitability.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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