Assessing the performance of chickpea cultivars in Mandi district of Himachal Pradesh, India

ABSTRACT

This study assessed the yield gaps of chickpea (*Cicer arietinum* L.) in Mandi district of Himachal Pradesh where a total of 240 trials on improved chickpea cultivars viz. GNG 1581, GPF 2 and Himachal Chana 2 along with best practices were conducted by KVK in Mandi for three consecutive years under the Cluster Front Line Demonstration (CFLDs) program during Rabi 2015-16 to Rabi 2017-18. The study revealed that the demonstration yield of chickpea cultivars viz. GNG 1581, GPF 2 and Himachal Chana 2 were significantly better than the farmer's practice. Overall, a seed yield of 616 kg ha^{-1} was achieved in the three years of data collected in the demonstration plot, which was 40.32 percent higher than the farmer's practice. The technology and extension gap in the data collected under the three-year CFLDs program were 1546.5 kg ha^{-1} and 177 kg ha^{-1} respectively. The improved technology package not only improved water use efficiency, chickpea profitability in terms of gross and net returns, but also improved the benefit-cost ratio (BC). The overall technology index of 71.51 percent revealed a satisfactory performance of technology interventions, which can be further strengthened in the region by bridging the gaps through more effective research and extension services.

Keywords: Chickpea, Technology gap, Extension gap, Technology index, Water use efficiency

1. INTRODUCTION

Pulses occupy a unique position in the Indian agricultural economy next to cereals and oilseeds in terms of acreage, production and economic value, accounting for 25% of global production (Pooniya*et al.* 2015). Cultivation of legumes is known for several benefits, including fixing atmospheric nitrogen in their root nodules and thereby improving soil fertility status (Singh *et al.* 2017). Legumes are an inexpensive, rich source of plant protein, vitamins, minerals, and lysine, including essential amino acids that are scarce in grain proteins (Wood and Grusak 2007 and Mohmoud 2009). It has twice the protein content of wheat and three times that of rice (Shukla *et al.* 2013). Chickpea, pigeon pea, mungbean, urdbean, lentil and field pea are important pulses grown in India (Ali and Gupta 2012). India is the largest producer of chickpea (*Cicer arietinum* L.) in the world, accounting for 65 percent of total production (Merga and Haji 2019). In 2017-18, 10.56 million ha of chickpea cultivation area was reported with a production of 11.23 million tons and a productivity of 10.63qha^{-1}, accounting for about 40 percent of total pulse production (Anonymous 2018). Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Uttar Pradesh and Gujarat are the major pulse producing states, contributing > 90 percent to chickpea production in the country.

To increase pulse productivity Govt. of India has launched a massive program like setting up seed hubs and infrastructure for quality seed production by involving KVKs across the country in large-scale technology demonstrations through Cluster Front Line Demonstrations (CFLDs) to encourage farmers to grow pulses and adopt new technologies. While KVK plays an important role by demonstrating site-specific best practices in pulse production, there is still a wide gap between potential yield and yield actually achieved in farmer-field situations due to non-availability of quality seed, cultivation on marginal and submarginal lands (Chandra 1994, Choudhary 2013). Bridging this yield gap offers an opportunity to harvest untapped potential and increase legume productivity. Pulses have not gained much popularity in the hill state of Himachal, which is grown in marginal areas, despite having the best quality and importance for a sustainable farming system. However, the shifting focus of the state administration on zero-budget organic farming, where pulses are an integral part of sustainable production, has led to increased interest in pulses by farmers and there is ample scope for increasing the area under pulses in the state. Apart from this, chickpea is also grown as the sole crop in some districts bordering Punjab and Haryana in the state, but it is not enough to meet the required demand of the people. Hence, emphasis was placed on the promotion of pulses, especially chickpea, with the intervention of KVK through demonstrations of new HYVs and best management technologies in the district to increase acreage and production. This paper assessed technology and extension gaps that could be useful to policy makers, researchers and extension workers in formulating strategies for further intensification of chickpea acreage in the region.

2. MATERIAL AND METHODS

The study was conducted in Mandi district of Himachal Pradesh, India under rainfed conditions. CSKHPKV, KVK, Mandi (HP) conducted Cluster Front Line Demonstration (CFLD) on improved farming technology of chickpea cultivars GNG 1581, GPF 2 and Himachal Chana 2 for three consecutive years (Rabi 2015-16 to Rabi 2017-18) in an area of 50.79 ha of 13 clusters covering 240 farmers. A full package of recommended practices was demonstrated on CFLD plots, while farmers' practices in adjacent farm fields were taken as control/local control (Table 1).

Table 1: Detail of technology demonstrated under CFLD on chickpea and farmers' practice

Particulars	Technology demonstrated under CFLDs	Farmers practice (Local check)
Variety	GNG 1581, GPF 2, Himachal Chana 2	Mixture/Himachal Chana 1
Seed rate	40 kg ha^{-1}	50-60 kg ha^{-1}
Seed treatment	Rhizobium + PSB	-Nil-
Sowing method	Line sowing	Broadcasting
Fertilizer dose	30:60:30 Kg NPK ha^{-1}	-Nil-
Plant protection	Need-based	-Nil-
Technical guidance	Time to time	-Nil-

“Yield data for both the improved practice and farmer practice were recorded and analyzed to draw conclusions. Fisher's Least Significant Difference (LSD) was used to analyze the difference in mean between demonstration plot yield (DPY) and farmer plot yield (FPY) using the following formula” (Yadav *et al*. 2018).

$$LSD_{0.05} = t\sqrt{MSW\left(\frac{1}{N1}+\frac{1}{N2}\right)}$$

Where;

t = Critical value from t distribution table,

MSW = Mean square within, obtained from the results of the ANOVA test,

N_1 = Number of observation of the first group,

N_2 = Number of observation of the second group,

The yield increase in demonstrations over farmers' practice was calculated using the following formula (Choudhary *et al.* 2009, Yadav *et al.* 2015, Yadav *et al.* 2017, Yadav *et al.* 2018):

$$\textbf{Increase in yield over farmer's practice}(\textbf{YIOFP}\ \%) = \frac{\text{Demonstration Plot Yield (DPY)} - \text{Farmer's Plot Yield (FPY)}}{\text{Farmer's Plot Yield (FPY)}} \text{x}100$$

The technology gap, extension gap and technology index were estimated using the following formulae (Samui *et al.*2000, Kadian*et al.* 1997, Dwivedi *et al.* 2014; Yadav *et al.* 2018):

$$\textbf{Technology gap}(\textbf{kg ha}^{-1}) = \text{Potential Yield (PY)} - \text{Demonstration Plot Yield (DPY)}$$

$$\textbf{Extension gap}(\textbf{kg ha}^{-1}) = \text{Demonstration Plot Yield (DPY)} - \text{Farmer's Plot Yield (FPY)}$$

$$\textbf{Technology Index}(\textbf{TI}\ \%) = \frac{\text{Potential Yield (PY)} - \text{Demonstration Plot Yield (DPY)}}{\text{Potential Yield (PY)}} \text{ x } 100$$

Economic analysis of CFLD's

The cost of cultivation in the demonstration plot included the cost of critical inputs, i.e. seed; fertilizers, bio-fertilizers, herbicides, pesticides etc. were supplied to farmers either by CSKHPKV, KVK, Mandi (HP) or invested by farmers. According to farmers' practice, it included the cost of inputs that farmers purchased. Gross and net yields were calculated accordingly taking into account cultivation costs and grain prices (Choudhary *et al.* 2009, Yadav *et al.* 2015, Yadav *et al.* 2017, Yadav *et al.* 2018).

Water use and water use efficiency

Since the demonstrations were conducted in the rainfed conditions, water use and water use efficiency were processed according to the method of Choudhary *et al.* 2009 and Choudhary 2013. "Seasonal water use (Et) is calculated from the contribution of profile water (CS), effective precipitation (ER) and applied irrigation water (I) using the equation: Et = CS + ER + I. Proportion of profile water (CS) was not taken into account on demonstration plots and farmers' plots due to different agro-ecological conditions. Hence, the water use efficiency was worked out considering the effective rainfall during the crop growth period in this study. The rainfall data was taken from the Agro Meteorological Observatory of KVK Mandi". [29]

3. RESULTS AND DISCUSSION

Seed yields under chickpea cultivars

The seed yield data of chickpea cultivars demonstrated through CFLD are presented in Table 2. The average of 88 demonstrations on an area of 12.29 ha revealed that chickpea Cv. GPF 2 recorded comparatively higher yield (735 kg ha^{-1}) than GNG 1581 (695 kg ha-1) during rabi 2015-16. During rabi 2016-17, chickpea cultivars GNG 1581 and Himachal Chana 2 were demonstrated with 56 demonstrations in an area of 18.50 ha where these varieties recorded seed yield of 580 and 596 kg ha^{-1} with 28.32 and 31.86 percent additional yield compared to farmer practice respectively (Table 2).

Table 2: Performance of chickpea cultivars demonstrated under CFLDs in Mandi district of Himachal Pradesh

Year	Variety under DP	No. of demonstrations	Area (ha)	Yield (Kg ha^{-1})		$LSD_{0.05}$	YIOFP (%)
				DPY*	FPY**		
2015-16	GNG 1581	84	11.51	695	420	21.36	65.48
2015-16	GPF 2	4	0.78	735	420	266.08	75.00
2016-17	GNG 1581	45	15.00	580	452	39.94	28.32
2016-17	Himachal Chana 2	11	3.50	596	452	86.18	31.86
2017-18	GNG 1581	80	15.00	557	450	23.29	23.78
2017-18	Himachal Chana 2	16	5.00	576	450	70.35	28.00
2015-16 to 2017-18	Pooled data	240	50.79	616	439	16.62	40.32

* DPY: Demonstration plot yield; **FPY: Farmers plot yield

These two cultivars demonstrated during Rabi 2017-18 in an area of 20 ha covering 96 trials again performed better and recorded 23.78 and 28.00 percent increased yield over the farmer's practice. Overall, a seed yield of 616 kg ha^{-1} was achieved in the three years of data collected in the demonstration plot, which was 40.32 percent higher than the farmer's practice. The seed yield on the demonstration plots was significantly higher in all years compared to farmer practice, which proves the superiority of the improved cultivars. In addition, the demonstration of a complete package of practices in a demonstration plot may be another reason for the visible impact of these cultivars, which were otherwise not followed by farmers within their traditional cropping system. The chickpea pod borer (*Helicoverpaarmigera*) is the most dreaded pest of this crop, taking a high toll on production and requiring frequent pesticide applications; however, farmers in the region hardly use any pesticide or ignore the pest at the most critical time of its initial build-up. In the demonstration plots, farmers were not only educated on pest identification, but also provided with critical inputs to effectively manage the pest, resulting in higher yields. Increase in yield due to adoption of improved farm technology has also been reported in earlier FLD studies (Kumari *et al.* 2007, Choudhary *et al.* 2009, Choudhary 2013, Sharma *et al.* 2012; Kumar *et al.* 2014, Singh *et al.* 2015, Kumbhare *et al.* 2014, Kumar *et al.* 2015, Yadav *et al.* 2018).

Technology and extension gap

The data presented in Fig. 1 revealed that the technology gap ranged from 1304 to 1843 kg ha^{-1} for the demonstrated technologies during the observed periods. The highest technology gap in chickpea cultivar GNG 1581 was observed during Rabi 2017-18 (1843 kg ha^{-1}), followed by Rabi 2016–17 (1820 kg ha^{-1}), while the lowest during Rabi 2015–16 (1705 kg ha^{-1}). Likewise, a technology gap of 1324 kg ha^{-1} was observed in chickpea cultivar Himachal Chana 2 during Rabi 2017-18 followed by 1304 kg ha^{-1} during Rabi 2016-17.

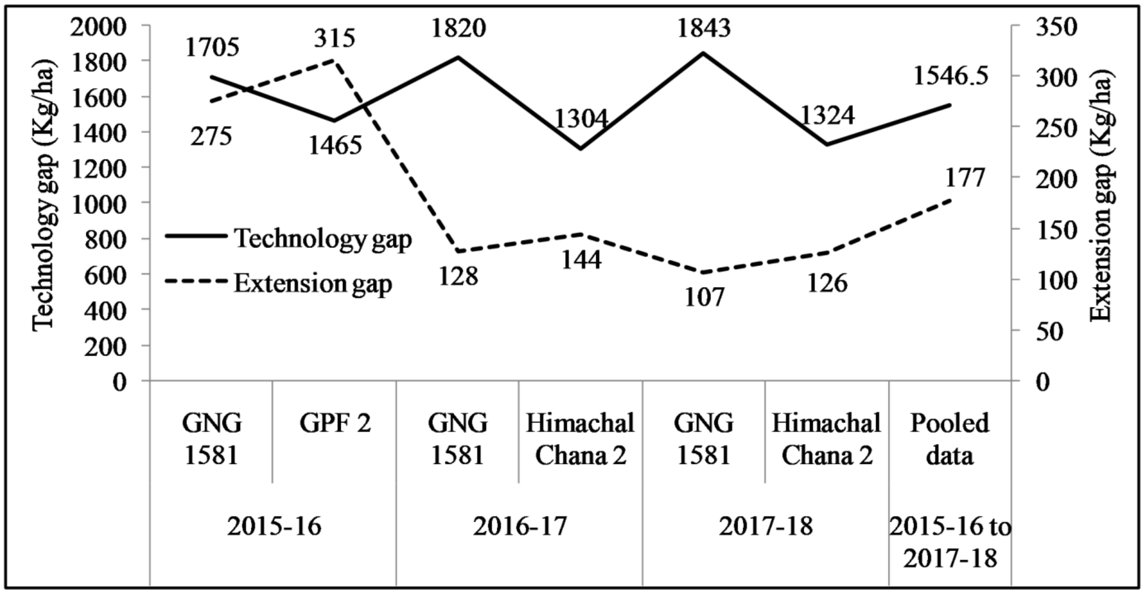

Fig 1: Yield gaps in chickpea cultivars under CFLDs in Mandi district of Himachal Pradesh

The overall technology gap based on the data collected for the three-year CFLD program was 1546.5 kg ha^{-1}. The cause of these deficiencies can be various biophysical factors, such as differences in soil fertility status, adverse microclimatic conditions and specific crop management problems (Yadav *et al.* 2017, Yadav *et al.* 2018). “Therefore, site-specific crop management is suggested to bridge the gap between potential yield and demonstration yields. Earlier, different workers also reported similar findings in their respective studies” (Choudhary 2013, Kumar *et al.* 2015, Yadav *et al.* 2018).

The results presented in Fig. 1 showed that the extension gap ranged between 107 kg ha^{-1} to 315 kg ha^{-1} and chickpea cultivar GPF 2 recorded the highest extension gap. For chickpea cultivar GNG 1581, the highest extension gap of 275 kg ha^{-1} was observed during Rabi 2015-16 followed by Rabi 2016-17 and 2017-18. The study also revealed that Cv. Himachal Chana 2 recorded 144 kg ha^{-1} extension gap during Rabi 2016-17 followed by Rabi 2017-18 (Fig. 1). On an average, extension gap for three consecutive years of the CFLD program was 177 kg ha^{-1}. Extension gaps are indicators of a lack of awareness among farmers about improved farm technologies (Yadav *et al.* 2015, Yadav *et al.* 2017, Yadav *et al.* 2018), and effective agricultural extension can bridge this gap (Evenson 1997, Oladele 2004). “Thus, there is a strong need to educate farmers through various extension means such as CFLDs, capacity building and provision of quality seed along with basic critical inputs to minimize these gaps”. [29]

Technology index

“The technology index indicates the feasibility of the technology under existing agro-climatic conditions” (Kumari *et al.* 2007, Choudhary *et al.* 2013, Kumar *et al.* 2015, Yadav *et al.* 2017, Yadav *et al.* 2018). A lower technology index value means a higher feasibility of improved technology and vice versa.

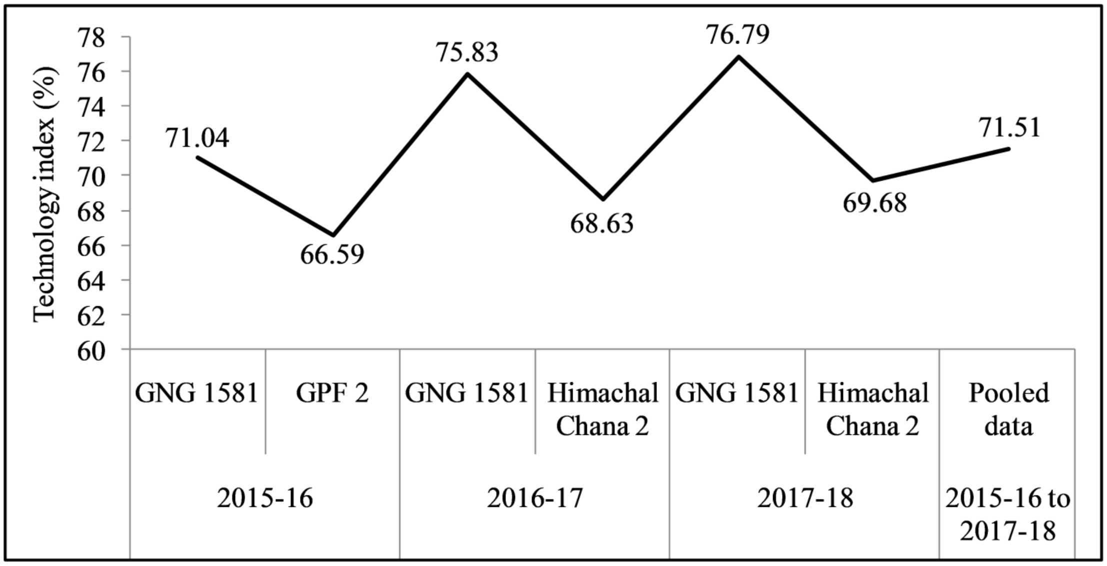

Fig 2: Technology index under different chickpea cultivars demonstrated through CFLDs in Mandi district of Himachal Pradesh

The data presented in Fig. 2 revealed that the lowest technology index (66.59%) was observed in chickpea cultivar GPF 2 followed by Himachal Chana 2 (68.63 - 69.68%) and GNG 1581 (71.04 -76.79), which may be due to the fact that GPF 2 and Himachal Chana 2 are well acclimatized in microclimatic conditions as these cultivars are recommended for cultivation in state by State Agricultural University, Palampur. On the other hand, GNG 1581 was introduced in the district recently. Overall, the technology index of 71.51 percent observed in the pooled data showed a satisfactory performance of technology interventions and potential for further adoption of this technology in the region. Pooniya*et al.* 2015 also reported 54.7-65.8 percent technology indexfor different chickpea cultivars, highlighting the urgent need to sensitize and educate farmers to adopt technologically feasible and economically viable farming technologies to increase yields and profitability.

Economic analysis

The economic analysis of the demonstrated technology under CFLD compared to farmer practice shown in Table 3 revealed that the highest net returns of Rs. 21,806 ha^{-1} was observed for chickpea cultivar GPF 2, followed by Himachal Chana 2 (17,143 ha^{-1}) and GNG 1581 (16,591 ha^{-1}).

Table 3 : Economic analysis of chickpea cultivars demonstrated under CFLDs

Chickpea cultivars	Gross cost (Rs.ha^{-1})		Gross return (Rs.ha^{-1})		Net return (Rs.ha^{-1})		BC ratio	
	DPY*	FPY**	DPY*	FPY**	DPY*	FPY**	DPY*	FPY**
GNG 1581	36129	31307	52720	38267	16591	6959	1.46	1.22
GPF 2	36994	29922	58800	33600	21806	3678	1.59	1.12
Himachal	35697	32000	52840	40600	17143	8600	1.48	1.27

Chana 2								
Pooled data	36273	31076	54787	37489	18513	6412	1.51	1.21

* DPY: Demonstration plot yield; **FPY: Farmers plot yield

Average net returns of Rs. 18,513 ha^{-1} obtained by the demonstrated technology in pooled data of all cultivars was much higher than the farmer's practice, which can be attributed to the adoption of improved technologies. Various workers have previously reported increased monetary returns due to improved farming technology (Chauhan *et al.* (2013), Choudhary 2013, Kumar *et al.* 2015, Yadav *et al.* 2015, Yadav *et al.* 2017, Kumar *et al*. 2019).

Water use and water use efficiency

The rainfall pattern during the cropping season in different years is shown in Fig. 3 and the water use and water use efficiency (WUE) data are shown in Table 4.

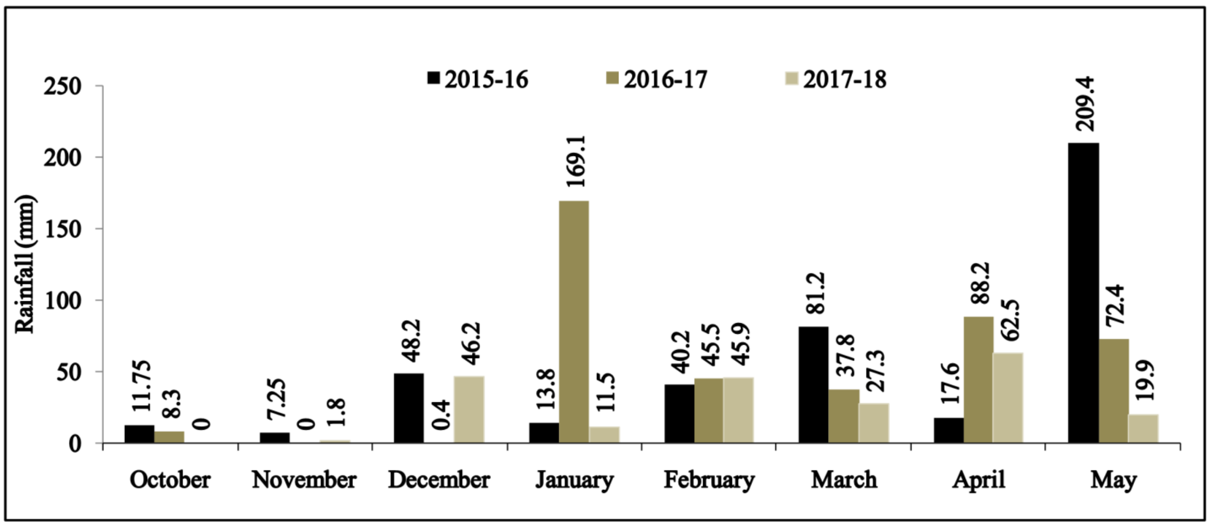

Fig 3 Rainfall pattern during the cropping season under different years of growing season

The data presented in Table 4 showed that the total seasonal water use during the crop growth period ranged from 215.1 mm to 429.4 mm with a mean of 355.4 mm. Water use efficiency (WUE) ranged between 1.41 and 2.68 kg ha^{-1} mm within the demonstration plots in this study. The total WUE was observed as 1.73 kg ha^{-1} mm under the demonstration plot, which was higher than the farmer plots.

Table 4 : Seasonal water use and water use efficiency under CFLDs on chickpea in Mandi district of Himachal Pradesh

Year	Variety under DP	Seasonal water use (mm)	Water use efficiency (kg ha^{-1} – mm)	
			DP*	FP**
2015-16	GNG 1581	429.4	1.62	0.98
2015-16	GPF 2	429.4	1.71	0.98

2016-17	GNG 1581	421.7	1.38	1.07
2016-17	Himachal Chana 2	421.7	1.41	1.07
2017-18	GNG 1581	215.1	2.59	2.09
2017-18	Himachal Chana 2	215.1	2.68	2.09
Average	Pooled data	355.4	1.73	1.24

* DP: Demonstration plot; **FP: Farmers plot

The adoption of improved agricultural technologies in the demonstration plot may have improved WUE compared to the farmers' plots, although crop water use was the same in both situations. Similar type of findings were previously reported by Choudhary *et al.* 2006 and Choudhary 2013.

4. CONCLUSION

The study conclusively showed that all three chickpea cultivars viz. GNG 1581, GPF 2 and Himachal Chana 2 demonstrated with a complete package of practices under the CFLD program gave better seed yields as well as higher profitability over farmers' practices. These cultivars not only improved WUE even under rainfed conditions but also highlight the scope for further productivity improvement if irrigation facilities are strengthened in the region. However, certain gaps appeared, which are mainly attributed to environmental and managerial factors. Environmental factors cannot be narrowed down, but management factors are manageable and can be bridged by deploying more effective research and extension services. This legume is of particular importance as it lends itself well as an intercrop with wheat and mustard and could also be grown as an intercrop under Zero Budget Natural Farming (ZBNF) for sustainable production. Therefore, extension workers should come forwardand set their priority for up-scaling of these technologies in the region.

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