Original Research Article

Assessing yield gaps for enhancing chickpea (*Cicer arietinum* L.) productivity in Mandi district of Himachal Pradesh, India

ABSTRACT

The present study assessed the technology and extension yield gaps in chickpea (*Cicer arietinum* L.) in Mandi district of Himachal Pradeshwhere a total of 240 demonstrations on improved chickpea cultivars *viz.* GNG 1581, GPF 2, and Himachal Chana 2 along with best practices were conducted by KVK, Mandi consecutively for three years under Cluster Front Line Demonstration (CFLDs) programme during *Rabi* 2015-16 to *Rabi* 2017-18. The study revealed that the demonstration plot yield of chickpea cultivars *viz.* GNG 1581, GPF 2 and Himachal Chana 2 was significantly superior over the farmer's practice. Overall, seed yield of 616 kg ha^{-1} was obtained in three years pooled data under demonstration plot which was 40.32 percent higher than the farmer's practice. The technology and extension gap in pooled data under the three-year CFLDs programme was 1546.5 kg ha^{-1} and 177 kg ha^{-1} respectively. Improved technology package not only improved the water use efficiency, profitability of chickpea in terms of gross and net returns but also enhanced benefit-cost ratio (BC). Overall technology index of 71.51 percent revealed satisfactory performance of technological interventions which can be further boosted in the region by bridging the gaps with more efficient 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 with a 25 per cent share in the global production (Pooniya*et al.* 2015). Pulses cultivation is known for several advantages including the fixation of atmospheric nitrogen in their root nodules and thus improving soil fertility status (Singh *et al.* 2017). Pulses are inexpensive rich source of plant-based proteins, vitamins, minerals, and lysine including essential amino acids which are scarce in cereal proteins (Wood and Grusak 2007 and Mohmoud 2009). It has double the protein content of wheat and thrice that of rice (Shukla *et al.* 2013). Chickpea, pigeon pea, mungbean, urdbean, lentil, and field pea are the important pulse crops grown in India (Ali and Gupta 2012). India is the largest chickpea (*Cicer arietinum* L.)producer in the world accounting for 65per cent of the total production (Merga and Haji 2019). During 2017-18, 10.56 Million ha of area was reported under chickpea cultivation with production of 11.23 Million tonnes and 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 of Chickpea production in the country.

To enhance pulse productivity Govt. of India started a massive programme like the creation of seed hubs and infrastructure for producing quality seeds by involving KVKs across the country for large scale technological demonstrations through Cluster Front Line Demonstrations (CFLDs) for encouraging farmers to grow pulses and adopt new technologies. The KVKs though have been playing an important role by demonstrating the site-specific best practices in the pulse production, but still, there is a wide gap between the potential yield and the yield actually achieved at the farmer's field's situations due to unavailability of quality seed, cultivation on marginal and sub-marginal lands, injudicious use of fertilizers and non-adoption of crop management practices and poor marketing infrastructure (Chandra 1994, Choudhary 2013). Bridging this yield gap offers an opportunity to harvest the untapped potential and increase the productivity of pulses. The pulses have not gained much popularity in the hilly state of Himachal being cultivated in marginal lands inspite of best quality and importance for the sustainable farming system. However, the shifting focus of state government on organic/ zero budget natural farming where pulses are an integral component for sustainable production has resulted in increased interest of farmers in pulses and there is ample scope to increase the area of pulses in the state. Apart, chickpea is also grown as a sole crop in some districts adjoining Punjab and Haryana of the state but not sufficient enough to meet the required demand of the people. The emphasis, therefore, has been on the promotion of pulses especially chickpea with the intervention of the KVKs by demonstrating the new HYVs and best management technologies in the district to increase the acreage and production. In the present paper, technology and extension gaps were assessed which would be helpful for policy planners, researchers, and extension workers for framing up of strategies for further intensification of the acreage of chickpea cultivation in the region.

2. MATERIAL AND METHODS

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

Table 1 : Detail of technology demonstrated under CFLDs 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 the improved practice as well as farmers' practice were recorded and analyzed to draw the inferences. Fisher's Least Significant Difference (LSD) was employed to analyze the difference in mean between the Demonstration plot yield (DPY) and Farmer's plot yield (FPY) by using the following formula (Yadav *et al.* 2018).

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

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):

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

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):

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

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

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

Economic analysis of CFLD's

Cost of cultivation in demonstration plot included the cost of critical inputs i.e. seed, fertilizers, bio-fertilizers, herbicide, pesticide, *etc.* were either supplied to the farmers by the CSKHPKV, KVK, Mandi (HP) or invested by farmers. Under the farmer's practice, it included the cost of inputs purchased by the farmers. The gross and net returns were worked out accordingly by taking cost of cultivation and price of grain (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 under rainfed situations, water use and water use efficiency were worked out by following the method of Choudhary *et al.* 2009 and Choudhary 2013. The seasonal water use (Et) is computed from profile water contribution (CS), effective rainfall (ER) and irrigation water applied (I) using the equation: Et = CS + ER + I. The profile water contribution (CS) was not taken into consideration in demonstration plots as well as farmers' plots due to the varying agro-ecological conditions. Thus, water use efficiency was worked out by taking in to account the effective rainfall received during the crop growth period in the present study. The rainfall data was taken from the Agro meteorological Observatory of KVK Mandi.

3. RESULTS AND DISCUSSION

Seed yields under chickpea cultivars

The data concerning seed yield of chickpea cultivars demonstrated through CFLDs have been presented in Table 2. The average of 88 demonstrations covering an area of 12.29 ha revealed that chickpea c.v. 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 580 and 596 kg ha^{-1} seed yield with 28.32 and 31.86 percent additional yield advantage over the farmer's practice respectively (Table 2).

Table 2: Performance of chickpea cultivars demonstrated under CFLDs 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 demonstrations again performed well and recorded 23.78 and 28.00 percent increased yield over the farmer's practice, respectively. Overall, seed yield of 616 kg ha^{-1}was obtained in three years pooled data under demonstration plot which was 40.32 percent higher than the farmer's practice. The seed yield in demonstration plots was significantly higher over the farmer's practice in all the years proving the superiority of the demonstrated improved cultivars. Apart, demonstration of the complete package of practices under demonstration plot might be another reason for the visible impact of these cultivars which otherwise was not followed by farmers under their traditional system of cultivation. Chickpea pod borer (*Helicoverpaarmigera*) is the most dreaded pest of this crop taking a heavy toll of production necessitating frequent pesticidal application; however, farmers in the region hardly use any pesticide or ignore the pest at the most crucial time of its initial build-up. In the demonstration plots, not only the farmers were educated about the identification of the pest but also provided with critical inputs for effective management of this pest consequently resulting in higher yields. The yield enhancement through the adoption of improved farm technology has also been reported in earlier studies of FLDs' (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 technological gap ranged from 1304 to 1843 kg ha^{-1} under the demonstrated technologies during the periods under study. The highest technological 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, the technological 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.

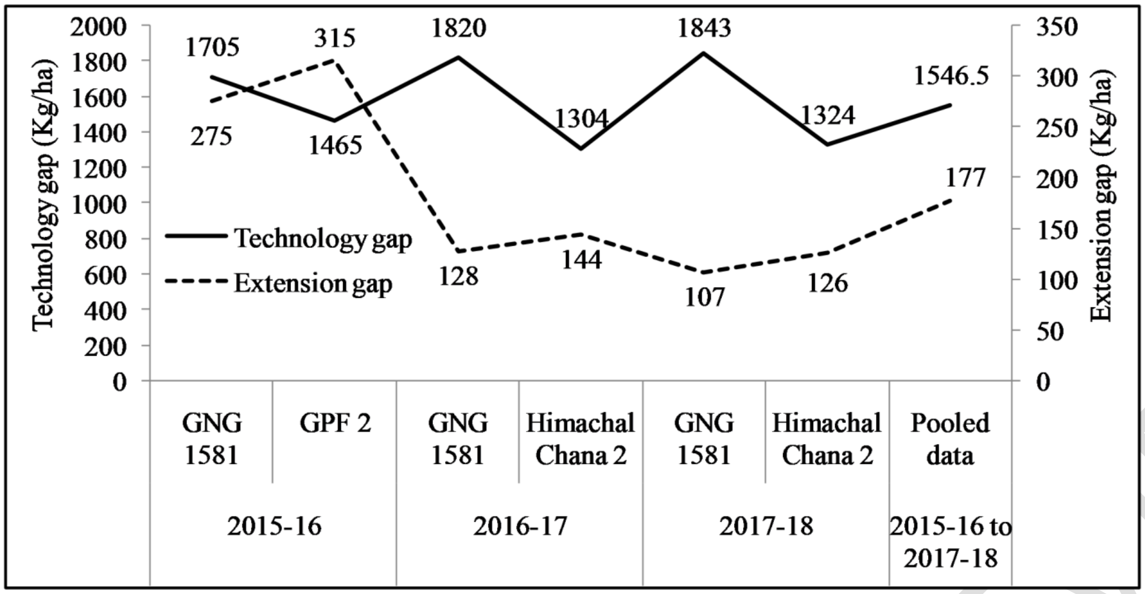

Fig 1: Yield gaps in chickpea cultivars under CFLDs in Mandi district of Himachal Pradesh

The overall technological gap based on pooled data for three years CFLDs programme was 1546.5 kg ha^{-1}. Various biophysical factors like dissimilarity in the soil fertility status, unfavorable microclimatic conditions, and specific crop management problems might be the reason for these gaps (Yadav *et al.* 2017, Yadav *et al.* 2018). Therefore, location-specific crop management is suggested to bridge the gap between potential yield and demonstration yields. Earlier, various 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 revealed 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. Under 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 respectively. The study also revealed that Cv. Himachal Chana 2 recorded 144 kg ha^{-1} of extension gap during *Rabi* 2016-17 followed by *Rabi* 2017-18 (Fig 1). On an average extension gap under three consecutive years of the CFLD programme was 177 kg ha^{-1}. The extension gaps are the indicators of lack of awareness for the adoption of improved farm technologies by the farmers (Yadav *et al.* 2015, Yadav *et al.* 2017, Yadav *et al.* 2018) and an effective agricultural extension can bridge the gap between research findings and farmers fields (Evenson 1997, Oladele 2004). Hence, there is a strong need to educate the farmers through various extension means i.e. CFLDs, capacity buildings, and providing quality seed along with essential critical inputs to minimize these gaps.

Technology index

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). Lower the value of technology index refers to the higher feasibility of improved technology and vice-versa.

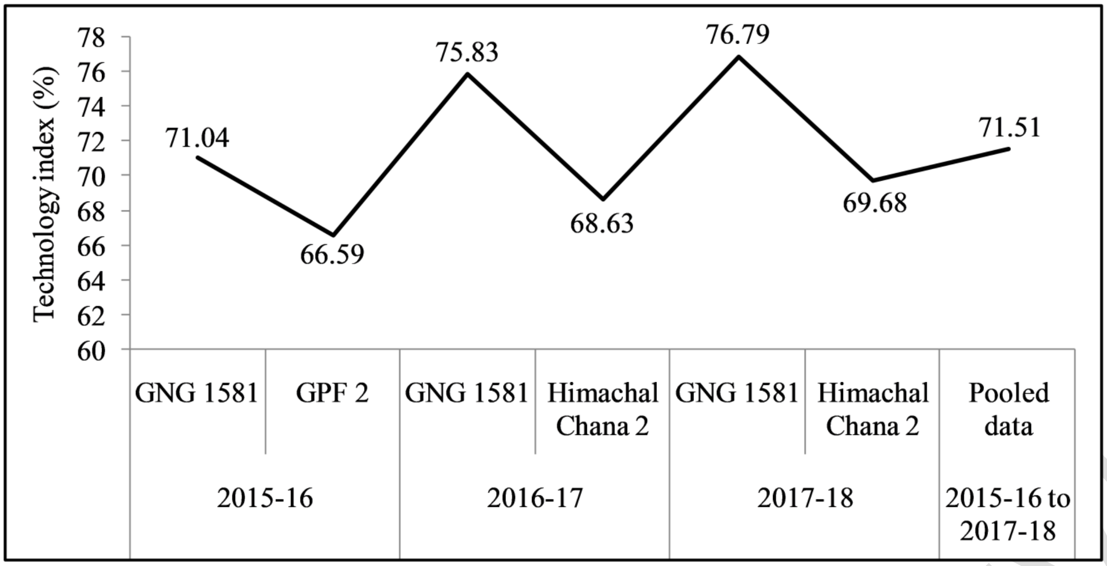

Fig 2: Technology index under different chickpea cultivars demonstrated through CFLDs in Mandi district of Himachal Pradesh

The data given in the Fig 2 revealed that least 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 the microclimatic conditions as these cultivars are recommended for cultivation in the state by CSKHPKV, Palampur. On the other hand, GNG 1581 has been introduced recently in the district. Overall, a technology index of 71.51 percent observed in pooled data of three years though showed the satisfactory performance of technological interventions and scope for further adoption of this technology in the region. Pooniya*et al.* 2015 also reported 54.7-65.8 percent of technology index in different chickpea cultivars emphasizing the urgent need to make aware and educate the farmers to adopt the technologically feasible and economically viable farm technology for enhancing yields and profitability.

Economic analysis

The variety wise economic analysis of demonstrated technology under CFLDs in comparison to farmer's practice presented in Table 3 revealed that the highest net returns of Rs. 21,806 ha^{-1} was observed in chickpea cultivar GPF 2 followed by HimachalChana 2 (Rs. 17,143 ha^{-1}) and GNG 1581 (Rs. 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 Chana 2	35697	32000	52840	40600	17143	8600	1.48	1.27
Pooled data	36273	31076	54787	37489	18513	6412	1.51	1.21

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

The average net returns of Rs. 18,513 ha^{-1} obtained under the demonstrated technology in pooled data of all cultivars was much higher than the farmer's practice which may be attributed to improved technologies. Enhanced monetary returns through improved farm technology have also been earlier reported by various workers (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 under different years has been given in Fig. 3 and data concerning water use and water use efficiency (WUE) have been presented in Table 4.

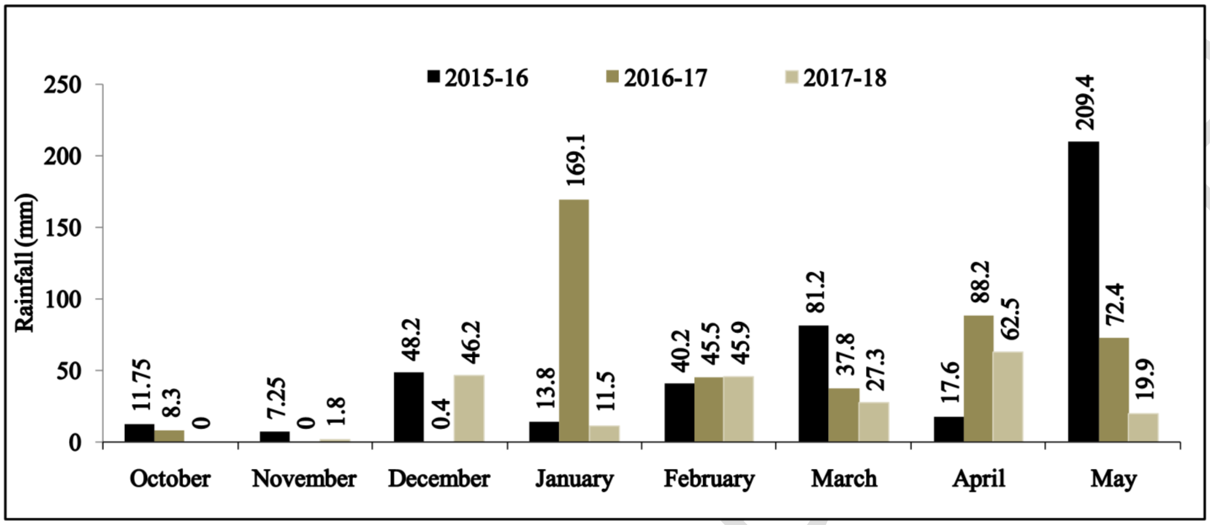

Fig 3 Rainfall pattern during the cropping season under different years of growing season

The data given in Table 4 showed that total seasonal water use during crop growth period varied from 215.1 mm to 429.4 mm with average of 355.4 mm. The water use efficiency (WUE) varied between 1.41 to 2.68 kg ha^{-1} mm under demonstration plots in the present study. The overall WUE was observed as 1.73 kg ha^{-1} mm under demonstration plot which was higher than the farmer's 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 farm technologies under demonstration plot might have improved the WUE over farmers' plots though the crop water use was the same under both the situations. A similar type of findings was also earlier reported by Choudhary *et al.* 2006 and Choudhary 2013.

4. CONCLUSION

The study conclusively indicated that all the three cultivars of chickpea viz. GNG 1581, GPF 2 and Himachal Chana 2 demonstrated under CFLD programme along with best practices provided better seed yields as well as higher returns over farmer's practice. These cultivars not only enhanced the WUE even under the rainfed situations but also emphasize scope for further improvement in the productivity if irrigation facilities are strengthened in the region. However, some gaps mainly attributed due to environmental and management factors have emerged. The environmental factors could not be narrowed down but, management factors are manageable and can be bridged by deploying more efficient research and extension services. This legume crop holds special importance as it fits well as an intercrop with wheat and mustard and could also be cultivated as an intercrop under zero budget natural farming (ZBNF) for sustainable production. Therefore, it also draws the attention of the extension workers to up-scale these technologies to further intensify the acreage of chickpea in the region.

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