Indian J. Dryland Agric. Res. & Dev. 2023 38(1): 37-42 10.5958/2231-6701.2023.00008.8

Impact of Improved Technologies on Yield and Economics of Chickpea (*Cicer arietinum* L.) under Rainfed Conditions in Shiwalik Region of North-Western Himalayas

Vijay Kumar, Vivek Sharma* and S.C. Sharma

AICRPDA, PAU-Regional Research Station, Ballowal Saunkhri, S.B.S. Nagar-144 521, Punjab

*E-mail: sharmavivek2002@gmail.com

ABSTRACT: Frontline demonstration (FLD) is an effective means for enhancing the adoption of technology and reducing the yield gaps of the different crops. FLDs on chickpea were conducted in ninety six farmers' fields in the Shiwalik foothills of Northwestern Himalayas, India to demonstrate the impact of improved production practices (improved varieties, seed inoculation with biofertilizer and deep sowing with drill) on production and the economics of chickpea during 2011-12 to 2014-15 under rain-fed conditions. The improved production technologies recorded additional yield of 204 kg/ha, 170 kg/ha and 144 kg/ha with 28.3%, 24.2% and 22.1% increase in yield respectively, for improved varieties, seed inoculation with biofertilizer (*Rhizobium* consortia and PSB) and deep sowing with drill. The extension gap varied from 170-204 kg/ha and technology gap from 676-805 kg/ha. Technology index varied from 42.3-50.3%, which indicated further scope for improvement in chickpea productivity in this region. FLDs recorded higher mean benefit-cost ratio (BCR) of 2.08 in comparison to 1.69 for farmers practice. Thus, productivity of chickpea could be increased by adopting recommended improved management practices under rainfed conditions. Hence, there is a need to bridge the gap between technology generated and technology transferred, through effective extension techniques for the benefit of the farming community.

Keywords: Chickpea, frontline demonstrations, technology index, economics, productivity

Introduction

Food security has been a major area of concern in India for a long time. The green revolution in India was the result of a series of research, development, and technology transfer initiatives that brought self-reliance in food grain production in the nation (Choudhary and Suri, 2014). Agriculture plays a vital role in India's economy. 54.6% of the population are engaged in agriculture and allied activities, which contributed 17.4% to the country's Gross Value Added for the year 2016-17 (Government of India, 2018). Stagnant pulse production in India compared to population growth rate of 1.44% has led to the steady decline in per capita pulse availability over the past two decades (Indian Institute of Pulse Research, 2011). Thus, there is an enormous collective challenge for agricultural scientists, policy planners, extension workers, and the farming community to enhance and sustain pulse productivity. This can be achieved mainly by bridging yield gaps, besides area expansion and diversified production systems well equipped with appropriate pulse production technology already generated by the research institutions through appropriate technology transfer programmes to harness recent technological advancements (Choudhary and Suri 2014).

Pulses are a good source of protein and for the majority of the population in India they are the only source of dietary protein. India is the largest producer, consumer and importer of the pulses in the world (Mishra and Khare, 2017). During 2017, pulse cultivation in India was 34.9 m ha with production of 23.2 m tonne and productivity 6.6 q/ha, which is much lower than the global productivity of 10.1 q/ha (FAO, 2018).

Chickpea is an important pulse crop of the world which is having wider adaptability under varied agro-climatic conditions and is grown in 44 countries on five continents. It is a premier legume crop in India being cultivated during *rabi* season, covering an area of 9.5 m ha with production of 9.07 m tonnes and productivity of 9.5 q/ha. India is contributing the highest share in area (71.0%) and production (71.9%) of chickpea (FAO, 2018). In Punjab, it is grown on 258 thousand ha area with production of 150 thousand tonnes and productivity of 5.8 q/ha, which is almost half as compared to national productivity. Low productivity and net returns are the main reasons behind shrinking area under chickpea cultivation in the state as well as lower Shiwalik region. The pulse crops are generally cultivated on marginal lands having low soil fertility and under rainfed conditions. Moreover, improper variety selection, poor crop, nutrient, weed and irrigation management, etc. are responsible for the low productivity of pulses in the state.

Improved production technologies are available in the country, but they do not serve the purpose until adopted by the farmers. Large number of technologies evolved in the field of agriculture are not being accepted and adopted to the fullest extent by farmers. Frontline demonstration is the new concept evolved by the Indian Council of Agriculture Research (ICAR) with the main objective of demonstrating newly released crops, production technologies and management practices in the farmers' fields under different farming situations and different agro-climatic regions of the country. While demonstrating

Table 1: Particulars showing the details of chickpea cultivation under FLD and farmer practices

S. No.	Technology	Farmers Practice	Improved practices
1	Variety	Local/unknown variety from local market	PBG 1, PBG 5 and PBG 7
2	Spacing	Broadcasting of seed	Line sowing with row spacing of 30 cm.
3	Seed rate	50-60 kg/ha	45 kg/ha
4	Fertilizers	Only Farm Yard Manure 4-5 tonnes/ha	33 kg urea and 125 kg single super phosphate along with FYM
5	Bio Fertilizer	Not using bio-fertilizers	*Rhizobium* consortia and Phosphorus solubilising bacteria (PSB) recommended by PAU, Ludhiana
6	Sowing	Sowing by broadcasting	Deep sowing with seed drill

the technologies in the farmer's fields, the main objective is to study the factors contributing to higher crop production, field constraints of production, generate production data and feedback information. Frontline demonstrations on chickpea (on farmer's fields) were conducted to demonstrate the production potential and economic benefits of improved varieties, seed inoculation with biofertilizer and sowing method to the farmers and convincing the farmers to adopt improved production technologies of chickpea.

Materials and Methods

Study Area

FLDs were conducted on farmers' fields during 2011-12 to 2014-15 under rainfed conditions in lower shiwaliks of Punjab province of India. For this purpose Garshankar Block of district Hoshiarpur and Naude Majra block of district Rupnagar were selected to represent the study area of lower shiwaliks **(Figure 1).** This zone is located between 30º44′ and 32º32′ N latitude and 75º52′ and 76º43′ E longitude at an elevation of 300-500 m above mean sea level. The study area receives about 1054 mm of annual rainfall, 80 per cent of which is received during two and half months of the south-west monsoon period (July-September). Similarly, the time and the amount of rain during withdrawal of monsoon in September are quite uncertain. Early withdrawal of monsoon is common in this region, resulting in severe drought during the later part of the *kharif* season (July-September). It also affects the stand establishment of subsequent *rabi* (October-April) crop as upper soil layer dries up by the sowing time. Sometimes, it becomes impossible to sow a *rabi* crop on residual moisture due to inadequate soil moisture in the seed zone (Sharma *et al*., 2014). The soils of the farmers' fields were loamy sand to sandy loam in texture, neutral to saline (pH 7.5-8.2), low in organic carbon (0.16-0.37%) and available nitrogen and medium to high in available phosphorus (12.5-25.9 kg/ha) and potassium (164.2-456.6 kg/ha). Details of farmers' practices and improved practices are given in **Table 1.**

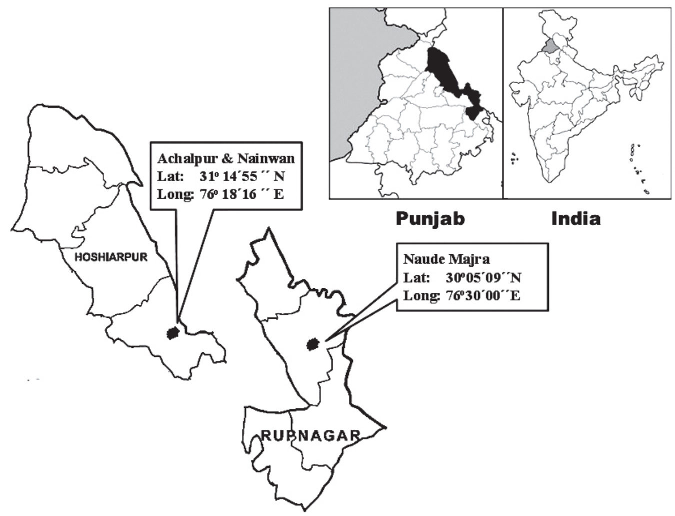

Fig. 1: Location of study villages in Hoshiarpur and Rupnagar Districts, Punjab, India

Identification of the constraints

The constraints in chickpea production were identified through participatory approach to popularize the improved varieties and crop management practices. The preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in chickpea production. Farmers were also asked to rank the constraints they perceive as limiting factor for chickpea cultivation in order of preference. Based on the top rank, farmers' problems were identified for chickpea production in the area and front line demonstrations were planned and conducted in the farmers' fields.

On-farm trials/FLDs

Ninety six Frontline demonstrations/on-farm trials were conducted by Regional Research Station, Punjab Agricultural University, Ludhiana, Punjab, India to demonstrate the effect of improved varieties, seed inoculation with biofertilizer (*Rhizobium* consortia and PSB) and deep sowing with drill on production and productivity of chickpea under rainfed conditions **(Table 1)**. Each demonstration was conducted in an area of 0.1 ha and adjacent plot to the demonstration plot was kept as farmers' practice.

The demonstrations were sown in the second fortnight of October to the first fortnight of November with the seed rate of 45 kg/ha and row spacing of 30 cm. All the crop production and protection practices as per the package of practices for *rabi* crops by Punjab Agricultural University, Ludhiana were followed for raising the crop. The average yield of the individual improved/ local practice for the four years was taken for interpretation of the results.

Estimation of crop productivity and yield enhancements

The primary data on grain yield was collected from the beneficiary farmers through random plot cutting methodology followed by personal interviews. One-way analysis of variance (ANOVA) of the data collected on improved and farmers' practice was done and as part of ANOVA, least significant difference (LSD) was computed using Fisher's method to statistically compare the difference between mean yields of improved and farmers' practice. The yield increase in frontline demonstrations over farmers' practice was calculated by using following formula (Choudhary *et al.,* 2009).

Estimation of technology gap, extension gap, and technology index

The extension gap, technology gap and technology index were calculated using the formula as suggested by Samui *et al*. (2000).

Extension gap (q/ha) = Demonstration yield (q/ha) - Farmers' yield (q/ha)

Technology gap (q/ha) = Potential yield (q/ha) - Demonstration yield (q/ha)

Technology index (%) = {Potential yield - Demonstration yield) / Potential yield} x 100

Economic Analysis of FLDs

The cost of cultivation of chickpea includes the cost of farm inputs (seed, fertilizers, pesticides, etc.) purchased by the farmers (in farmers' practice) /supplied for the FLDs as well as labour (hired/family), sowing charges, and harvesting operation charges. The gross and net returns were worked out accordingly by taking the cost of cultivation and the price of grain yield into consideration. Additional costs in FLDs include expenditure on improved technological inputs in FLDs over farmers' practice. Similarly, the incremental benefit-cost ratio (BCR) was worked out as a ratio of gross returns and cost of cultivation, as followed by Sharma *et al*. (2016).

Results and Discussion

Constraints in chickpea production

The problems faced by the farmers in chickpea cultivation were documented and preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in chickpea production. The rankings given by the farmers to different constraints are given in **Table 2.** A perusal of the table indicates that availability of improved variety seed (78%), disease incidence (68%), wild animal damage (65%) and insufficient soil moisture at sowing (55%) were the major constraints to chickpea production in the study area. Similar constraints in other crops have been reported by Meena *et al*. (2014), Sharma *et al*. (2016) and Kumar *et al*. (2017).

Table 2: Ranks given by farmers for different constraints

S. No.	Constraint	Percentage	Rank
1	Availability of improved variety seed	78	I
2	Disease incidence	68	II
3	Damage by wild animals	65	III
4	Insufficient soil moisture at sowing	55	IV
5	Low soil fertility	48	V
6	Low technical knowledge	42	VI
7	Post harvest management	36	VII

Crop productivity and yield enhancement

The yield of improved technologies was significantly higher than the farmers practice for all the technologies demonstrated in the FLDs **(Table 3).** The productivity of chickpea in the FLDs on improved varieties ranged between 690-1430 kg/ha with mean yield of 924 kg/ha, which was 28.3% higher over farmers' cultivars. The yield enhancement was mainly due to the better adaptation, higher yield potential and resistance/tolerance to biotic and abiotic stresses of the improved varieties compared to the farmers' cultivars. Similar enhancement in productivity of chickpea through front line demonstration on improved varieties was reported by Kumar *et al*. (2016), Yadav *et al*. (2016) and Mishra and Khare (2017).

The productivity in FLDs on seed inoculation with biofertilizer ranged between 680-1120 kg/ha with mean yield of 873 kg/

Table 3: Seed yield of chickpea as affected by improved and farmer practices in farmer fields

Technology	Area (ha)	Demon stration (No.)	Yield (kg/ha) Improved Technology (IT)			Farmer practice (FP)	LSD (0.05)	% increase in yield over farmers' practice	Ext. Gap (q/ha)	Tech. Gap (q/ha)	Tech. index (%)
			Maxi mum	Mini mum	Ave rage						
Improved variety	5.9	54	1430	690	924	720	91	28.3	204	676	42.3
Seed inoculation with biofertilzer	2.2	24	1120	680	873	703	83	24.2	170	727	45.4
Deep Sowing with drill	2.3	18	880	730	795	651	54	22.1	144	805	50.3

ha compared to 703 kg/ha from farmers' practice **(Table 3).** A 24.2% increase in yield over farmer's practice was observed in the FLDs on seed inoculation with biofertilizer. The yield enhancement may be mainly due to the nitrogen fixation by the biofertilizer during the seedling stage which resulted in better plant growth. Swarnalakshmi *et al*. (2016) reported that biofertilizers applied to plants may help to provide various nutrients and in turn, promote overall plant growth. They help plants in fixing nitrogen, solubilizing and extensively accessing phosphorus, combating abiotic stresses, bio-control and siderophore production.

FLDs on deep sowing with drill resulted in mean yield of 795 kg/ha with 22.1% yield increase compared to farmers' practice **(Table 3).** Sowing with a seed drill places the seed deeper in the soil, where soil moisture is higher, resulting in higher seed germination, better crop stand and ultimately higher yield. Sharma *et al*. (2016) have reported yield enhancement in wheat when sown with the seed drill under rainfed conditions.

Extension yield gaps

Extension gap is the difference in the yield of the demonstration and farmers' practices. The large extension gap in the current study indicates that there is a need to educate and motivate farmers to adopt improved pulse production technology. The successful development, dissemination, and adoption of improved technologies for farmers depends on careful research planning and use of appropriate extension methodologies (Cramb, 2003; Biggs and Smith 1998). Refinement of local farmers' practices for greater adoption of location-specific farm technology for sustaining crop productivity is another option open for the extension scientists (Choudhary *et al*., 2010). Extension gap **(Table 3)** varied from 144 to 204 kg/ha for different technologies demonstrated through FLDs which may be due to lack of knowledge among farmers regarding the improved production technologies. It shows that extension agencies have to make efforts for the effective transfer of the recommended technology to the farmers' fields. Extension gap emphasizes the need to educate the farmers through various means for the adoption of improved agricultural production technologies (Choudhary and Suri 2014).

Technology yield gap

Technology gap, which indicates the gap between potential yield (1600 kg/ha) and demonstration yields ranged between 676-805 kg/ha **(Table 3)**. Generally, technologicy gap appears even if the FLDs are conducted under the strict supervision of the scientists in the farmers' fields. The observed technology gap may be due to dissimilarity in the soil fertility status, ill distribution of rainfall and cultivation under rainfed conditions and marginal lands (Kumar *et al*. 2015; Sharma *et al*., 2016). The wide gap between the potential yield and demonstration yields indicates the need to develop location specific recommendations with full package of practices to minimize the technology gap for yield level under different situations (Vedna *et al*., 2007; Choudhary and Suri 2014). Such steps would boost the production of this crop and encourage the farmers to enhance area under this crop.

Technology index

Technology index in the present study was 42.3% for improved varieties, 45.4% for seed inoculation with biofertilizer and 50.3% for deep sowing with drill **(Table 3)**. The high values of technology index indicate that there is further scope for improvement in productivity of chickpea. The crop was cultivated during *rabi* season under rainfed conditions, facing water stress due to ill distribution of rainfall during the growth period besides greater incidence of gram pod borer in chickpea which resulted in poor yields. Further, the variation in yield from location to location can be attributed to prolonged dry spell (2-3 months) during initial growth period of the crop, varying climatic condition and variation in agricultural practices followed. The current study also stresses that technology packages under rainfed pulses should be combined with location-specific moisture conservation technology so that these crops could perform better in farmers' fields (Choudhary and Suri 2014).

Economic analysis

Economic analysis of improved technologies over farmer's practices was calculated depending on the prevailing market prices of inputs and outputs **(Table 4)**. The extra cost of cultivation for improved varieties, seed inoculation with bio-fertilizer and deep sowing with drill over farmers' practices were 1532/-, 237/- and 156/- Rs/ha respectively. Additional

Table 4: Cost of cultivation (Rs/ha), net return (Rs/ha) and benefit cost-ratio (BCR) of chickpea as affected by improved and farmer practices

Technology	Cost of cultivation (Rs/ha)		Net returns (Rs/ha)		Additional cost of cultivation (Rs/ha)	Additional net returns (Rs/ha)	B:C Ratio	
	IT	FP	IT	FP			IT	FP
Improved variety	18,745	17,213	22,374	12,931	1,532	9,443	2.23	1.76
Seed inoculation with biofertilizer	19,261	19,024	15,659	9,123	237	6,536	1.81	1.47
Deep sowing with drill	16,270	16,114	17,900	12,372	156	5,528	2.20	1.85

net returns of 9443/-, 6,536/- and 5,528/- INR/ha were realized with improved varieties, seed inoculation with biofertilizer and deep sowing with drill, respectively over farmers' practices, suggesting higher profitability and economic viability of the FLDs. Benefit cost ratios were also higher for the improved practices compared to farmers' practices. These results are in agreement with the findings of Kumar *et al*. (2016) and Mishra and Khare (2017) who have also reported higher net returns and BCR in FLDs compared to farmers' practices. The results of the present study clearly brought out the potential of improved production technologies in enhancing chickpea production and net returns under rainfed farming situations.

Conclusion

FLDs on chickpea conducted in farmers' fields revealed that the adoption of improved production technologies significantly increased the yield and net returns. Non-availability of improved varieties of chickpea was a major constraint expressed by the beneficiaries, followed by disease incidence, wild animal damage and insufficient soil moisture at sowing. There was a wide gap between potential crop yields, demonstration yields, and farmers' plot yields in chickpea due to technology and extension gaps. This highlights the need for further refinement of technology generated with special attention on cultivation under rainfed conditions. Hence, location specific recommendations should be developed and farmers should be encouraged to adopt these recommendations for the increasing yields and economic benefits.

Acknowledgement

We sincerely thank all the farmers of different villages on whose fields frontline demonstrations were conducted. The financial assistance and technical support provided by All India Coordinated Research Project for Dryland Agriculture, National Initiative for Climate Resilient Agriculture (NICRA) and Directorate of Research, Punjab Agricultural University, Ludhiana is duly acknowledged. The views expressed in this paper are those of individual scientists and do not necessarily reflect the views of the donor or the authors' institution.

References

Anonymous. 2017. Statistical Abstracts of Punjab; http://esopb.gov.in/Static/PDF/ Publications/Statical-Abstract/Abstract2015.pdf.

Biggs SD and Smith G. 1998. Beyond methodologies: Coalition-building for participatory technology development. *World Development*, 26: 239-248.

Choudhary AK and Suri VK. 2014. Scaling up of pulse production under frontline demonstration technology transfer program in Himachal Himalayas, India. *Communications in Soil Science and Plant Analysis*, 45: 1934-1948.

Choudhary AK, Singh A and Yadav DS. 2010. On-farm testing of wheat cultivars for site specific assessment under varied bio-physical regimes in mid-hill conditions of Mandi District of Himachal Pradesh. *Journal of Community Mobilization and Sustainable Developemnt*, 5: 1-6.

Choudhary AK, Yadav DS and Singh A. 2009. Technological and extension yield gaps in oilseeds in Mandi District of Himachal Pradesh. *Indian Journal of Soil Conservation*, 37(3): 224-229.

Cramb RA. 2003. Processes affecting the successful adoption of new technologies by smallholders. pp 11-22 In, *Working with Farmers: The Key to the Adoption of Forage Technologies*, ed. B. Hacker,.: Australian Centre for International Agricultural Research (ACIAR), Canberra.

FAO. 2018. FAO Agricultural Production Statistics, http://fao.org/faostat/en/#data as accessed on 24 April, 2018.

Government of India. 2018. Annual report 2017-18; Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

Indian Institute of Pulse Research (2011). *Vision 2030*. Indian Institute of Pulse Research, Kanpur, India.

Kumar U, Sahu AK, Chouhan S and Kantwa SC. 2016. Enhancement of chickpea productivity through improved technology in farming community. *International Journal of Agricultural Sciences*, 8: 2755-2757.

Kumar V, Sharma V and Sharma SC and Singh S. 2017. Performance of high yielding drought tolerant varieties of maize and in situ moisture conservation techniques in Kandi region of Punjab, India; *Journal of Applied and Natural Sciences*, 9: 316-323.

Kumar V, Sharma V, Sharma SC, Singh S and Sharma RK. 2015. Productivity enhancement in sesame (*Sesamum indicum* L.) as influenced by different improved production technologies. *Journal of Oilseeds Research*, 32: 87-90.

Meena BL, Meena RP, Meena RR and Singh B. 2014. Popularization of improved maize (*Zea mays* L.) production technology through frontline demonstrations in semi arid zone IVA of Rajasthan. *Journal of Applied and Natural Sciences*, 6: 763-769.

Mishra PK and Khare YR. 2017. Performance of chickpea (*Cicer arietinum*) under frontline demonstration in Sagar district of Madhya Pradesh, India. *Plant Archives*, 17: 659-660.

Samui SK, Maitra S, Roy DK, Mondal AK and Saha D. 2000. Evaluation of front line demonstration on groundnut (*Arachis hypogea* L.) in Sundarbans. *Journal of Indian Society of Coastal Agricultural Research*, 18:180-183.

Sharma SC, Kumar V, Khokhar A, Singh S and Sharma V. 2014. Four Decades of Dryland Agricultural Research in Kandi Area of Punjab (1971-2010); Regional Research Station (PAU), Ballowal Saunkhri.

Sharma V, Kumar V, Sharma SC and Singh S. 2016. Productivity enhancement and popularization of improved production technologies in wheat through frontline demonstrations. *Journal of Applied and Natural Sciences*, 8: 423-428.

Swarnalakshmi K, Yadav V, Senthilkumar, Mand Dhar DW. 2016. Biofertilizers for higher pulses production in India: Scope, accessibility and challenges. *Indian Journal of Agronomy*, 61: S173-S181.

Vedna K, Kumar A, Kumar A and Bhateria S. 2007. Demonstration: An effective tool for increasing the productivity of rapeseed-mustard in Kangra District of Himachal Pradesh; *Himachal Journal of Agricultural Research*, 33(2): 257-261.

Yadav SK, Rajput SKS, Tripathi M, Yadav R, Chandra S and Singh RK. 2016. Effect of front line demonstration for enhancing the yield of chickpea (*Cicer arietinum* L.). *Agriculture Update*, 11: 22-25.