



## Participatory Evaluation of Chickpea Production Technology under Central Punjab Conditions

Suman Kumari<sup>1\*</sup> and Harinder Singh<sup>2</sup>

<sup>1</sup>Assistant Professor, Krishi Vigyan Kendra, Kapurthala, Punjab, India

<sup>2</sup>Associate Director (Trg.) Krishi Vigyan Kendra, Jalandhar, Punjab, India

\*Corresponding author email id: suman60@pau.edu

### ARTICLE INFO

**Keywords:** Chickpea, Cluster frontline demonstrations, Economics, Technological gaps, Yield

<http://doi.org/10.48165/IJEE.2023.59321>

**Conflict of Interest:** None

### ABSTRACT

Cluster Front Line Demonstrations (CFLD's) of chickpea variety PBG7 on 82 locations were conducted to document the economic viability of technology dissemination in central plain conditions of Punjab during 2019-20 and 2020-21 to evaluate chickpea production technology. The demonstrations created an average yield production of 17.80 q/ha, which was 21.03 per cent greater than the traditional farming method (14.70 q/ha). Because of significant variation in the extent of adoption of recommended technology the yield levels were much lower under local practices. Other economic parameters like more B:C ratio (3.63), gross return (57220/ha), and net return (40465.5/ha) were comparatively more under advanced technology demonstrated plots. An average extension gap, technology gap, technology index, and additional returns of chickpea were recorded at 3.09 q/h, 2.2 q/ha, 11% and Rs. 14485/ha, respectively. Variations in agro-climatic factors and management practices were found to be responsible for variations in the technology gap and index percentage which can be reduced by farmer's participation in adopting new technologies. It is concluded that by opting for new variety and management practices there is a huge scope to increase chickpea production at different strata viz, farmer, district, state and national level.

### INTRODUCTION

Despite an exponential increase in food grain production from 50 million tones to about 300 million tones after independence, food security is still the most threatening and challenging issue for ever fast-growing country like India. However, in order to ensure national food security, pulses can play very significant role. They are frequently termed as “underprivileged population’s food.” who cannot afford other protein rich foods and become an answer to mall nourished population of India. Among pulses, chickpea (*Cicer arietinum* L.) commonly called chana or Bengal gram which is predominantly grown in Northern India, is a very crucial pulse crop. It is a significant rabi pulse crop with 18-22 per cent protein, 62 per cent carbohydrates and good amount of fat, lysine

and tryptophan (Meena et al., 2021). It is a very beneficial crop as it fixes nitrogen from the environment and contributes in organic carbon to soil which ultimately improves soil productivity level.

In India, 10 million hectares of chickpea were grown in 2020-21 producing 11.91 million tons with an average productivity of 11.92 quintals per hectare (Kumar, 2023). Under Punjab conditions, it was grown in 2,000 hectares of land with a yield of 2.6 thousand tones along with an average productivity of 13.22 quintals per hectare (PAU, 2022). Although, India contributes 26 per cent in international market of pulses, India's average productivity is still quite low i.e. 841 kg/ha, compared to the international average of 1023 kg/ha (DES, 2018). The per-person availability of pulses in India was 60.70 g/day per person in 1951 which had declined sharply to 31.6 g/day/person in 2010 (Singh et al., 2020 & Kumar

& Singh, 2021). This steep decline occurs because of exponential increase in population in combination with low production and productivity of chickpea because of lack of knowledge about improved scientific cultivation practices. However, to meet country’s demand for pulses, still Indian government relies heavily on export from international market. So, for the uninterrupted production of pulses, CFLDs was initiated by the Indian government financed by National Food Security Mission. The frontline demonstrations can have a significant impact on farmers’ adoption level about advanced scientific cultivation practices as they are firm believer of “Seeing is believing” theory. The present CFLDs were executed with an objective to attain the full productivity potential by boosting current production and productivity of the chickpea and to close yield gap by exhibiting the most advanced and cutting-edge scientific crop management techniques at farmer’s fields in a participatory manner.

**METHODOLOGY**

Under National Food Security Mission Scheme, 82 CFLDs were conducted on a 36 ha area across two blocks of Kapurthala district in 2019-20 and 2020-21. Among 82 CFLDs, 37 demonstrations were conducted in Sultanpur Lodhi block and 45 in Kapurthala blocks, respectively. For conducting CFLDs, farmers were identified on the basis of group meetings. It was noted that full gap was found in weeds management, improved varieties, fertilizers and seed rate, whereas, partial adoption gap was recorded in land preparation, sowing schedule, sowing method and irrigation schedule. These selected farmers were trained with specific skill training that includes advised crop production and plant protection measures for raising the crop. These demonstrated technologies were according to recommendations of the Punjab Agricultural University, Ludhiana and comprised of improved variety of chick pea PBG 7, appropriate tillage, accurate seed rate, a balanced fertilizer application approach. Farmers’ practise (FP) was employed as a check/control during these demonstrations. To know the impact of demonstrated technologies, regular field visits of demonstration plots were conducted by KVK scientists. In order to conduct CFLDs in best way, field days, kisan goshties, trainings, field days and group meetings were also executed. These extension activities serve as a means, to create awareness and to show the benefits of adopted technologies to the farming community. At harvesting time to understand the significance of imparted technologies, the yield data from farmers practice plot and demonstrated plot was recorded and pooled. The formulas provided

by Dayanand (2012) were used to compute percent increase in yield, technology gap, technology index and extension gap.

$$\text{Extension gap} = \text{yield of demonstrated plot (Dy) (kg/ha)} - \text{Yield of plot under farmer practice (kg/ha)}$$

$$\text{Technology gap} = \text{Potential yield (Py) (kg/ha)} - \text{Yield under improved practice (kg/ha)}$$

$$\text{Technology index (\%)} = \frac{\text{Py} - \text{Dy}}{\text{Py}} \times 100$$

$$\text{Percent increase in yield} = \frac{\text{Increase of yield under demonstrated plot (q/ha)} - \text{increase of yield under farmers plot (q/ha)}}{\text{increase of yield under farmers plot (q/ha)}} \times 100$$

$$\text{Additional returns} = \text{Demonstration returns} - \text{Farmers practice}$$

$$\text{Insect-pest/disease incidence (\%)} = \frac{\text{Damaged plants}}{\text{healthy plants}} \times 100$$

$$\text{Additional cost (Rs./ha)} = \text{Demonstrated technology cost} - \text{farmer practice cost}$$

$$\text{Effective gain (Rs./ha)} = \text{Additional returns of demonstrated practice} - \text{Additional cost of demonstrated technology}$$

$$\text{Yield Gap I} = \frac{[(\text{Potential yield (YP)} - \text{yield of demonstration plot (YD)})/\text{YP}] \times 100}$$

$$\text{Yield Gap II} = \frac{[(\text{yield of demonstration plot (YD)} - \text{yield of farmer’s plot (YF)})/\text{YD}] \times 100}$$

**RESULTS AND DISCUSSION**

**Impact of CFLDs on reduction of insect-pest population**

Cluster frontline demonstrations studies were conducted in Kapurthala district of Punjab during 2019-20 and 2020-21 in the *rabi* season. According to this two year study, it was discovered that enhanced technology performed most effective in controlling least number of attacked plants per m<sup>2</sup> as well as least number of pods/plants (Table 1). The average per cent reduction in attacked plants per m<sup>2</sup> and per cent reduction in affected pod/plant were recorded 45.4 and 42.4, respectively. Similarly, in 2020-21, under demonstrations, number of pods per plant and seed index was 40.4 and 21.9, respectively over the farmer practices results (31.6 and 15.4). The percent increase in number of pods per plant was 27.84 after following recommended practices. The average yield under demonstrated plots was 17.7 q/ha whereas, in farmer practice plots it was 14.7 q/ha.

The per cent increase in yield in improved technology fields was 20.4 over traditional practices. This data clearly showed the impact of advanced technology over farmer practices as enhanced

**Table 1.** Effect of scientific interventions on insect-pests in chickpea

Year	Number of pods/plant			Reduction percentage of attacked plants/m <sup>2</sup>	Reduction percentage of attacked pods/plant	Yield		Impact (% change)
	DP	FP	Percent increase			Demonstration	Farmer practice	
2019-20	38.7	30.9	25.2	46.4	43.3	17.3	14.2	21.9
2020-21	40.4	31.6	27.84	44.4	41.6	18.2	15.2	19.7
Average	39.5	31.3	26.5	45.4	42.5	17.7	14.7	20.4

DP: Demonstration plot; FP: Farmer’s plot (Local check)

seed yield. Similar trend of yield enhancement under frontline demonstrations was documented by Dwivedi et al., (2013); Sakti et al., (2016) and Meena and Singh (2017) who highlighted the concept of integrated pest management practices in enhanced yield of chickpea through frontline demonstration.

### Technology gap, extension gap and technology index

During the study, average technology gap of 2.20 q/ha (Table 2) was calculated during demonstration period. It reflects that there is further potential for production growth with improved technologies, so that farmers can achieve the potential yield. The findings are in confirmation with that reported by Kumbhare et al., (2014); Nain et al., (2014); Nain et al., (2015); Vijya Lakshmi (2017); Singh et al., (2019); Mitra & Samajdar (2010); Sharma et al., (2020) that in order to tackle this situation, area specific cultivation practices, are need to be developed. The difference between demonstrated yield and yield under demonstrated existing farmer practice is extension gap. An extension gap of 3.12 and 3.06 q/ha (Table 2) was calculated during 2019-20 and 2020-21, respectively. On an average, extension gap observed during both the years was 3.09 q/ha which is a wide gap. The alarming trend of the increased extension gap would be reduced by educating farmers regarding adoption of different recommended practices by various extension (cluster frontline demonstration training programmes, awareness campaigns, and media coverage etc.) and research related programmes in conjunction with high yielding varieties. Present finding is in corroboration with the findings of Meena et al., (2020); Hiremath & Nagaraju (2010); Ojha & Bisht (2020); Singh et al., (2019). Technology index is represented as ratio of potential yield to technology gap as a percentage. An increased technology index value indicated inadequate transfer of tested technology to growers and inadequate extension facilities, while a lower technology index number indicates a higher likelihood of improved technology. Technology index observed under

improved technology plots during different years 2019-20 and 2020-21 was 13.3 and 8.7, respectively (Table 2). It indicated the possibility of adoption of new variety by the farmer and technical interventions' efficiency (Dudhade, 2009). Mitra & Samajdar (2010) also emphasized on the need to bridge the technology gap index by means of specific area suitable interventions. In addition to this, Singh et al., (2019) also reported that by implementing better technological intervention, the technological gap can be reduced; that will ultimately lower down the technology index.

### Impact of scientific interventions on yield component of chickpea

The technological interventions employed in pulse crops consists of improved cultivars, method of sowing, recommended seed rate, integrated nutrient management, seed treatment, weed control techniques, and appropriate plant protection measures results in improved productivity.

It is evident from the results that the average seed yield was 17.80 q/ha in demonstrated plot in comparison to control plots where it was 14.70 q/ha (Table 3). The highest average chickpea productivity i.e. 18.26 q/ha was recorded in 2020-21 followed by 17.34 q/ha in 2019-20. These results clearly revealed the importance of introduced interventions over farmer practices as there was 21.03 per cent increase in yield recorded in improved practices plots in comparison to local/check plot practices. The yield parameter also compared at district, state and national level productivity and it was recorded significantly more at district, state and national level productivity. The outcome made it evident that in demonstrated technology plots, the average productivity increased by 71.1, 32.0 and 120.8 per cent over district, state and national yields, respectively. There is variety of reasons responsible for the increased chickpea production, like adoption of improved variety, scientific package of practices, integrated pest management, micro irrigation at critical growth stage, bio fertilizer seed treatment, and judicious application of pesticides.

Present findings clearly demonstrate higher yield under adopted practices in comparison to farmer's practices. Similar results were documented by Rajpoot (2020) that when compared to farmers' methods (11.2 q/ha), better technologies yielded a chickpea yield of 18.8 q/ha. The present findings are corroborated by findings of other workers like Kumar et al., (2010); Dwivedi et al., (2011 & 2013); Khedkar et al., (2017); Ojha & Bisht (2020); Singh et al., (2018) Poonia & Pithia (2011); Patel et al., (2013);

**Table 2.** Extension parameters studied under CFLD and local/check practice in Kapurthala district

Year	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
2019-20	2.66	3.12	13.3
2020-21	1.74	3.06	8.70
Average	2.20	3.09	11.0

**Table 3.** Yield attributes of demonstrated chickpea variety PBG7

Year	Demo.	Av. yield of DP (q/ha)	Av. yield of FP (q/ha)	% increase in yield	Dist. Av. yield	State Av. yield	Nat. level Av.	Potential yield (q/ha)	Improved tech. yield (q/ha)	% change in yield over dist. (q/ha)	% change in yield over state (q/ha)	% change in yield over national (q/ha)	Yield gap I (%)	Yield gap II (%)
2019-20	42	17.34	14.22	21.94	10.4	13.75	8.06	20.0	3.12	66.7	26.1	115.1	13.3	17.9
2020-21	40	18.26	15.2	20.13	10.4	13.22	8.06		3.06	75.6	38.1	126.6	8.7	16.75
Average	82	17.8	14.7	21.03	10.4	13.48	8.06		3.09	71.1	32.0	120.8	11	17.32

Av: Average; DP: demonstrated practice; FP: farmer's practices; Dist.: district; Nat: national

**Table 4.** Economics of chickpea CFLDs in Kapurthala district

Year	COC (Rs./ha)		ACOC in IT (Rs./ha)	Sale price (Rs./q)	COC increase over FP (%)	AGR (Rs./ha)		Increase in GR over FP (%)	AR in IT (Rs./ha)	ANR (Rs./ha)		Increase in NR over FP (%)	EG (Rs./ha)	BCR	
	IT	FP				IT	FP			IT	FP			IT	FP
2019-20	14959	14200	759	3600	5.34	55655	42125	32.12	13530	40696	27925	45.13	12771	3.72	2.96
2020-21	16550	14900	1650	3800	11.07	58785	43345	35.62	15440	40235	28445	41.44	11790	3.55	2.90
Average	15754.5	14550	1204.5	3700	8.21	57220	42735	33.89	14485	40465.5	28185	43.57	12280.5	3.63	2.93

COC: Cost of Cultivation; IT: improved technology; FP: Farmer practice; ACOC in IT: Average cost of cultivation in Improved technology; AGR: Average gross return; AR: Additional return; ANR: Average Net return; EG: Effective gain; BCR: Benefit cost ratio

Raj et al., (2013); Gireesh et al., (2019); Kumari & Singh (2022) also reported increase in yield under frontline demonstrations on pulses and oilseed crops.

### Yield gap and economics

Projected yield gaps between potential and farmers' yields, including yield gap between potential and demonstrated plot yield (YG1); demonstrated and local/check plot yield (YGII) and complete yield difference between potential and farmer's yield are presented in Table 4. The average yield gap I and II was 11 and 17.32 per cent, respectively. Similar results were documented by Singh et al., (2012 and 2019); Sultana et al., (2019); Tripathi et al., (2018). During the present study wide yield gap was calculated among district, state and national yield which can be reduced by providing farmers with education through a variety of channels to encourage the use of better production and defense techniques along with combination of high yielding varieties and integrated plant protection components will subsequently revert this vast yield disparity pattern. Similar findings were quoted by Dubey et al., (2022) that yield gap at farmers' fields could be minimized if large scale demonstration repeated over time along with easy access to high yielding varieties.

Economics acts as a cornerstone for both embracing and rejecting technology which depends upon number of factors like seed yield, variable input costs, labour costs, and output sale prices. Compared to farmers' practices, improved technological interventions increased the average cost of agriculture by 8.21 per cent (Table 4). On the basis of current market rates, the economics of upgraded technology under CFLDs were assessed. On average basis, an additional investment of Rs. 1204.5/ha was recorded under demonstrated technology plots. Similarly, the cost of cultivation was increased by 8.21 per cent after introduction of scientific techniques in demonstration plots. In addition to these, other returns like greater average gross return (57220), maximum additional net returns (40465.5/ha), high effective gain (12280.5/ha), an additional returns (14485/ha) and increased benefit: cost ratio (3.63) was recorded under improved intervention plots, whereas in under farmer's practice plots there was visible fall in these parameters, like less gross return (42735/ha), decreased net return (28185/ha) and low benefit cost ratio (2.93). The farmers' increased gross financial returns demonstrate the technology's economic viability. At demonstrated plots the expenditure involved is higher because of additional cost of cultivation than the farmers' field. Yet, the demonstrated plot also has a higher yield, which is

supported by calculated cost-benefit ratio. Raghav et al., (2021) observed similar findings where more B:C ratio was recorded under demonstrated practices over check plots. Similar economic benefits after adoption of improved technologies like high cost benefit ratio, high yield and maximum net return under frontline demonstrations on pulses were documented by Dwivedi et al., (2011); Dwivedi et al., (2014); Meena & Singh (2017); Reager et al., (2020); Singh et al., (2018) & Singh et al., (2019).

### CONCLUSION

Approach of CFLDs is proved good not only for adopters but also for the rest of the farming community, as they are conducted under supervision of the scientists with proper framework of technologies. These performed technologies have a sustained effect on chickpea productivity as the maximum yield potential (21.94%), high net return (40696/ha) and B:C ratio of 3.72 could be obtained only after following all improved technologies. The gaps related to extension, technology, adoption, yield and technology index must be lower down by popularizing the technologies through different extension means. Apart from these factors, high economic returns serve as the prime factor to disseminate them among farmers for adoption at large scale. Therefore, close association of agricultural scientists and extension functionaries along with timely allocation of funds plays a pivotal role in elevating farmer livelihoods, state agriculture production, and India's agricultural output to achieve new heights in pulses production.

### REFERENCES

- Dayanand, V. R. K., & Mehta, S. M. (2012). Boosting mustard production through front line demonstrations. *Indian Research Journal of Extension Education*, 12(3), 121-123.
- DES. (2018). Directorate of Economics & Statistics, department of agriculture cooperation & welfare, ministry of agriculture, Government of India, New Delhi.
- Dubey, S. K., Gautam, U. S., & Singh, A. (2022). Pulses yield gap minimization: consequences of CFLD-Pulses in India. *Indian Journal of Extension Education* 58(3), 65-69.
- Dudhade, D. D., Deshmukh, G. P., Harer, P. N., & Patil, J. V. (2009). Impact of frontline demonstration of chickpea in Maharashtra. *Legume Research*, 32(3), 206-208.
- Dwivedi, A. P., Mishra, A., Singh, S. K., Singh, S. R. K., & Singh, M. (2014). Yield gap analysis of chickpea through front line demonstration in different agro-climatic zones of M.P. and Chhattisgarh. *Journal of Food Legumes*, 27(1), 50-63.

- Dwivedi, A. P., Singh, R. P. & Singh, M. (2011). Effect of technological interventions on yield & economics of pigeon pea in eastern U.P. *Indian Journal of Extension Education*, 47(3&4), 65-68.
- Dwivedi, S. V., Anand, S. K., & Singh, M. P. (2013). Varietal performance of oilseeds & pulses at farmers field in Vindhyan zone under rain fed condition. *Technofame -A Journal of Multi Disciplinary Advance Research*, 2, 25-31.
- Gireesh, S., Kumbhare, N. V., Nain, M. S., Kumar, P., & Gurung, B. (2019). Yield gap and constraints in production of major pulses in Madhya Pradesh and Maharashtra. *Indian Journal of Agricultural Research*, 53(1), 104-107.
- Hiremath, S. M., & Nagaraju, M. V. (2010). Evaluation of on-farm front line demonstrations on the yield of chilli. *Karnataka Journal of Agricultural Sciences*, 23(2), 341-342.
- Khedkar, R., Shinde, V., & Chaudhari, P. (2017). Role of cluster frontline demonstrations in enhancement of chickpea production. *Journal of Krishi Vigyan*, 6(1), 172-174.
- Kumar, A. (2023). Agricultural Statistic at a glance, Department of Agriculture and cooperation, Directorate of Economics and Statistics, Ministry of Agriculture and Farmer welfare, Government of India. Pg. 42-43. [https://agricoop.nic.in/Documents/CWWGDATA/Agricultural\\_Statistics\\_at\\_a\\_Glance\\_2022\\_0.pdf](https://agricoop.nic.in/Documents/CWWGDATA/Agricultural_Statistics_at_a_Glance_2022_0.pdf)
- Kumar, P., Peshin, R., Nain, M. S., & Manhas J.S. (2010). Constraints in pulses cultivation as perceived by the farmers. *Rajasthan Journal of Extension Education*, 17&18, 33-36.
- Kumar, U., Patel, G. A., Patel, H. P., Chudhari, R. P., & Darji, S. S. (2021). Impact of frontline demonstration programme on the yield of chickpea (*Cicer arietinum* L.) in Patan district of Gujarat, India. *Legume Research*, 44(2), 221-224.
- Kumari, S., & Singh, J. (2022). Impact of frontline demonstrations on oilseed production in Kapurthala district of Punjab. *Journal of Agricultural Development & Policy*, 32(2), 142-147.
- Kumbhare, N. V., Dubey, S. K., Nain, M. S., & Bahal, R. (2014). Micro analysis of yield gap and profitability in pulses and cereals. *Legume Research- An International Journal*, 37(5), 532-536.
- Meena, M. L., & Singh, D. (2017). Technological & extension yield gaps in green gram in Pali district of Rajasthan, India. *Legume Research*, 40(1), 187-190.
- Meena, R. K., Singh, B., Chawla, S., Meena, R. K., & Shinde, K. P. (2021). Evaluation of frontline demonstrations of chickpea under irrigated North Western Plain Zone-1b of Rajasthan. *Journal of Pharmacognosy & Phytochemistry*, 10(1), 1240-1244.
- Meena, R. K., Singh, B., Shinde, K. P., & Meena, R. K. (2020). Cluster front line demonstrations of green gram under national food security mission in Sriganganagar district: an evaluation of production & productivity of green gram. *International Journal of Current Microbiology and Applied Sciences*, 9(6), 984-990.
- Mitra, B., & Samajdar, T. (2010). Field gap analysis of rapeseed mustard through front line demonstration. *Agricultural Extension Review*, 22, 16-17.
- Nain, M. S., Bahal, R., Dubey, S. K., & Kumbhare, N. V. (2014). Adoption gap as the determinant of instability in Indian legume production: Perspective and implications. *Journal of Food Legumes*, 27(2), 146-150.
- Nain, M. S., Kumbhare, N. V., Sharma, J. P., Chahal, V. P., & Bahal, R. (2015). Status, adoption gap and way forward of pulse production in India. *Indian Journal of Agricultural Sciences*, 85(8), 1017-1025.
- Ojha, R. K., & Bisht, H. (2020). Yield potential of chickpea through cluster frontline demonstrations in Deoghar district of Jharkhand. *International Journal of Science, Environment & Technology*, 9(6), 947- 954.
- Patel, M. M., Jhaharia, A. K., Khadda, B. S., & Patil, L. M. (2013). Front-line demonstration: an effective communication approach for dissemination of sustainable cotton production technology. *Indian Journal of Extension Education & Rural Development*, 21, 60-62.
- PAU. (2022). *Package of Practices for Cultivation of Rabi Crops*, 22 pp. Punjab Agricultural University, Ludhiana, India.
- Poonia, T. C., & Pithia, M. S. (2011). Impact of front line demonstrations of chickpea in Gujarat. *Legume Research*, 34(4), 304- 307.
- Raghav, D. K., Indrajeet, Dharamjeet, K., Kumar, A., Singh, A. K., & Chauhan, J. K. (2021). Role of cluster frontline demonstrations on chickpea for enhancing the production in Ramgarh of Jharkhand. *Indian Journal of Extension Education*, 21(1).
- Raj, A. D., Yadav, V., & Rathod, J. H. (2013). Impact of front line demonstrations on the yield of Pulses. *International Journal of Science & Research*, 3(9), 1-4.
- Rajpoot, S. K. S. (2020). Evaluation of frontline demonstration on chickpea (*Cicer arietinum* L.) in Sonbhadra district of U P. *International Journal of Current Microbiology & Applied Sciences*, 10, 206-212.
- Reager, M. L., Upender, K., Mitharwal, B. S., & Chaturvedi, B. S. (2020). Productivity and sustainability of green gram as influenced by improved technology of CFLD under hyper arid partially irrigated zone of Rajasthan. *International Journal of Current Microbiology and Applied Sciences*, 9(5), 1978-1986.
- Sakti, K., Rai, A. K., Kumar, R., Jadav, J. K., & Lata, K. (2016). Popularization of IPM practices for management of chickpea pod borer, through frontline demonstrations under semi-arid conditions. *Indian Journal of Extension Education*, 52(3 & 4), 117-121.
- Sharma, S. C., Kamruzzaman, M., & Siddique, S. T. (2020). Impact of improved chickpea cultivation on profitability & livelihood of farmers in drought-prone areas of Bangladesh. *Journal of Agriculture*, 18(1), 129-142.
- Singh, M., Dwivedi, A. P., & Yadav, K. S. (2019). Gaps in pulses production in Vindhya pleatue agroclimatic zone of Madhya Pradesh: an assessment through frontier technology. *Indian Journal of Extension Education*, 55(1), 39-42.
- Singh, N. K., Kumar, S., Singh, B. K., & Wajid, H. (2020). Impact of cluster frontline demonstration on yield of chickpea in Nalanda, Bihar. *Journal of Agri Search*, 7(1), 44-46.
- Singh, R. P., Singh, A. N., Dwivedi, A. P., Mishra, A., & Singh, M. (2012). Assessment of yield gap in chickpea through frontier technology. *Journal of Extension Education*, 17(1), 85-89.
- Singh, R., Dogra, A., Sarkar, A., Saxena, A., & Singh, B. (2018.) Technology gap, constraint analysis & improved production technologies for yield enhancement of barley (*Hordeum vulgare*) & chickpea (*Cicer arietinum*) under arid conditions of Rajasthan. *Indian Journal of Agricultural Sciences*, 88(2), 93-100.
- Sultana, R., Rahman, M. H., Haque, M. R., Sarkar, M. M. A., & Islam, S. (2019). Yield gap of stress tolerant rice varieties Binadhan-10 & Binadhan-11 in some selected areas of Bangladesh. *Agricultural Sciences*, 10, 1438-1452.
- Tripathi, A. K., Yadav, K. S., Singh, M., & Singh, D. K. (2018). Yield gap analysis of chickpea productivity through frontline demonstrations in Sagar district of Madhya Pradesh. *Indian Journal of Extension Education*, 54(2), 251-255.
- Vijay Lakshmi, D., Vijay Kumar, P., & Padma Veni, C. (2017). Impact of cluster frontline demonstrations to transfer of technologies in pulse production under NFMS. *Bulletin of Environment, Pharmacology and Life Sciences*, 6(1), 418-421.