www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(3): 1096-1101

www.thepharmajournal.com
Received: 03-01-2022
Accepted: 08-02-2022

Dhananjai Singh
Scientist, Department of Agronomy, Krishi Vigyan Kendra, Sidhi, Madhya Pradesh, India

RK Singh
Scientist, Department of Agronomy, Krishi Vigyan Kendra, Chhatarpur, Madhya Pradesh, India

AK Patel
Scientist, Department of Soil Science, Krishi Vigyan Kendra, Rewa, Madhya Pradesh, India

MS Baghel
Senior Scientist and Head, Krishi Vigyan Kendra, Sidhi, Madhya Pradesh, India

Corresponding Author:
Dhananjai Singh
Scientist, Department of Agronomy, Krishi Vigyan Kendra, Sidhi, Madhya Pradesh, India

Performance of chickpea (*Cicer arietinum* L.) var. JG 14 under late sown condition of Rice-Chickpea cropping system in Sidhi district of Madhya Pradesh

Dhananjai Singh, RK Singh, AK Patel and MS Baghel

Abstract
Chickpea is one of the most important pulse crop in India, which plays a major role in supplementing the income for small and marginal farmers of Sidhi district of Madhya Pradesh. The development of the Agriculture is primarily depending on the application of scientific technologies by making the best use of available resources. To increase the production, productivity, profitability and quality of agricultural produce, On Farm Testing and Front Line Demonstrations were implemented at various farmers' fields during rabi seasons of four selected blocks of Sidhi district of Madhya Pradesh. Krishi Vigyan Kendra, Sidhi conducted 60 on farm testing and frontline demonstrations of Chickpea in late sown condition of Rice- Chickpea cropping system during four consecutive years from 2013–14 to 2018–19. The critical inputs were identified in existing production technology through meetings and discussions with farmers. Prevailing farmer's practices were treated as a control for comparison with recommended practices. The average yield of recommended practices registered 42.6 percent higher than the farmer's practice. The average technology gap, extension gap and technology index were observed 7.30 q /ha, 3.20 q/ha and 40.6 percent respectively. The highest grain yield (11.4 q/ha) was recorded in the year 2017-18, it was 39.0 per cent more than the farmer's practice (8.20 q/ha). Average net profitability of worth Rs. 25023 /ha as compared with farmers practices (Rs. 16264/ha) were obtained an average benefit-cost ratio i.e. 2.91 and 2.46 were recorded in demonstrated plot and farmers practice respectively. The higher additional returns (Rs. 2003/ha) and effective gain (Rs. 6757/ha) obtained under demonstrations could be due to improved technology, timely of crop cultivation operations and scientific monitoring.

Keywords: OFT, FLD, Chickpea, JG 14, Yield, technology gap, technology index, net returns, effective gain and BC ratio

Introduction

India being 2nd most populated country in the world with domination of veg.-dietary habits still far from achieving sufficiency in pulse production. Pulses are rich and predominating source of protein with Recommended Dietary Allowances for adult male and female is 60 g and 55 g per day, while its per capita availability is only 42 g per day (Anonymous 2019) [6]. India is the largest producer and consumer of pulse with maximum area coverage in the world. Yet, with stagnation of production in spite of increase in demand, there has been an increasing demand supply gap for pulse in India which creates huge economic loads in term of import to meet out the domestic demands. According to the vision 2030 of ICAR- Indian Institute of Pulse Research, Kanpur growth rate of 4.2% has to be ensured to meet out projected demand of 32 MT of pulse by 2030 (Tiwari and Shivhare, 2017) [31]. In order to ensure self- sufficiency, the pulse requirement in the country is projected to be about 39 million tons by year 2050 which necessitates adoption of chickpea as a suitable option in Rabi season for higher crop productivity and profitability with improved soil health. Pulses are grown worldwide on an about 85.40 m ha with a production of 87.40 (Mt) at 1023 kg ha^{-1} yield level. India ranks first in term of area (29.3 M ha) and production (245 lakh tones) with 34 per cent and 26 per cent contribution, respectively (Anonymous 2018) [4].

Chickpea (*Cicer arietinum*) is one of the oldest pulse crops that have been grown for over 8,000 years (Dhuppar *et al.* 2012) [11]. Chickpea, a member of Fabaceae, is a self pollinated true diploid (2 n = 2 x = 16) with genome size of 738 Mbp (Varshney *et al.* 2013) [33]. It is an ancient cool season food legume crop cultivated by man and has been found in Middle Eastern archaeological sites dated 7500–6800 BC (Zohary and Hopf 2000) [35]. Its cultivation is mainly concentrated in semiarid environments (Saxena 1990) [25]. Chickpea is the second most important food legume crop after common bean (FAOSTAT 2011) [13].

It is grown in more than 50 countries on an area of 13.2 m ha, producing approximately 11.62 m tones annually. India ranks first in the world's production and area by contributing around 70.7% to the world's total production (FAOSTAT 2011) [13]. It is one of the most important food legume plants in sustainable agriculture system because of its low production cost, wider adaptation; ability to fix atmospheric nitrogen and fit in various crop rotations (Singh 1997) [27] and presence of prolific tap root system. Chickpea can fix atmospheric nitrogen up to 140 kg/ha through its symbiotic association with Rhizobium and meets its 80% requirement (Saraf *et al.* 1998) [24]. It also helps in enhancing the soil quality for subsequent cereal crop cultivation by adding organic matter for the maintenance of soil health and ecosystem. Deep and tap root system of chickpea is known to help in opening up of the soil to the deeper strata, ensuring better texture and aeration of the soil for next crop. It is a rich source of quality protein (20–22%) to the predominantly vegetarian population in Indian subcontinent, other South Asian countries and the Middle East. It has the highest nutritional compositions and free from anti-nutritive components compared to any other dry edible grain legumes, and thus, it is considered a functional food. Besides proteins, it is rich in fiber and minerals (phosphorus, calcium, magnesium, iron and zinc), and its lipid fraction is high in unsaturated fatty acids (Williams and Singh 1987) [34]. It has no anti-nutritional factors (Mallikarjuna *et al.* 2007) [18] and contains higher amounts of carotenoids like β-carotene than genetically engineered 'golden rice' (Abbo *et al.* 2005) [1]. Of the total production, the desi and kabuli chickpeas contribute around 80% and 20%, respectively. Kabuli type is mainly grown in temperate regions, while the desi type chickpea is grown mostly in the semiarid tropics (Malhotra *et al.* 1987) [19].

In terms of agricultural importance, pulses are next to cereal crops and are also known as excellent option for agriculture diversification and intensification in sustainable farming. India is the largest producer and consumer of pulses and contributes in about 35 per cent share in global area and production. India is the largest chickpea producing country, which is accounting for 64% of the global chickpea production (Gaur *et al.* 2010) [14]. In India, chickpea crop was grown in an area of 9.93 million hectares with the production of 9.53 million tons and the productivity of 960 kg/ha (Anonymous, 2014) [3]. Over the last six years, the on-going National Food Security Mission (NFSM) has been converged with multi-pronged strategies to enhance the production and productivity of pulses in the country (Anonymous, 2018) [5] which results in enhanced per hectare productivity. The year 2017-18 witnessed a record pulse production of 25.23 million tons (Anonymous, 2018) [4], a grand success story and revolution in pulses self-sufficiency.

The country is now trying to meet the target of 35 million tons by 2030 with the challenging reasons like unavailability of quality seed, lack of technical guidance, ignorance of Integrated Pest Management techniques and non-adoption of integrated nutrient management (Kumar *et al*. 2014; 2016) [16, 17]. Besides this, major abiotic stress i.e. low organic content in soil, low moisture content in the soil, types of soils, seasonal drought due to low rainfall are also responsible for low productivity of the pulses crops (Dubey *et al.* 2017) [12]. Among biotic stress, legume pod borer, *Helicoverpa armigera* (Hübner) is responsible for 50 to 60 per cent grain yield losses (Balikai *et al.* 2001) [7] and losses exceeded Rs.12,000 million per year (Anonymous, 1996) [2]. Therefore, it is a great deal for extension scientists, policy makers, and farming community to meet out the pulses availability demand over the country population in terms of household nutritional security.

The frontline demonstrations technology-transfer program (FLD-TTP) in pulses is conducted under the close guidance and supervision of extension and agricultural scientists. It is an initiative by the Ministry of Agriculture under the aegis of the government of India and is a form of adaptive research. As the frontline demonstrations works on the principle of learning by doing and seeing is believing, it makes them the most efficient and effective tool for the extension programs. It provides a close analysis of production constraints in existing farm practices and performance of improved farm technology under varied farming situations, for rapid transfer of technology to enhance productivity and farm income besides diversifying production systems for pulse self – reliance (Chaudhary *et al.* 2009) [10].

Keeping this in view, on farm testing and front line demonstrations of chickpea were conducted in order to demonstrate the productivity potential and economic benefit of improved technologies under late sown condition in rice-chickpea cropping system on farmers' field conditions. The main objective of the Demonstration was to: Demonstration of Plant nutrient and Plant protection centric improved technologies and management practices in a compact block covering large areas, enhance productivity of Pulses, area expansion of Pulses crops, stimulate other farmers of the adjoining area to adopt these technologies, bring fallow / barren land under Pulses cultivation with low inputs.

Materials and Methods

The present study was carried out in the Sidhi district of Madhya Pradesh, which is located in the North-East part of Madhya Pradesh state and lies at 24.395603 latitude and 81.882530 longitudes with an altitude of 272 m above the mean sea level. On farm testing and frontline demonstrations were conducted during 2013-14 to 2018-19 with evaluating the performance of the JG 14 variety of Chickpea in Sidhi, Majhauli, Rampur Naikin, Kusmi and Sihawal blocks of the district. In this study, 60 farmers were selected from aforesaid blocks during the study period. Total 60 front line demonstrations under real farming situations were conducted during *rabi* seasons of 2013-14 to 2018-19 in three blocks under Krishi Vigyan Kendra operational area.

The area under each demonstration was 0.4 ha. The soil was sandy clay-loam in texture with moderate water holding capacity, low to medium in organic carbon (0.034-0.055%), low in available nitrogen (118-212 kg/ha), medium in available phosphorus (10-14 kg/ha), low to medium in available potassium (206-303 kg/ha) and soil pH was slightly acidic to neutral in reaction (6.5-7.1). The treatment comprised of recommended practice (Improved variety JG-14, integrated nutrient management-@ 60:40:20:25 kg NPKS/ha + Rhizobium + PSB @ 5 g/kg seed, integrated pest management + seed treatment with *Trichoderma viridae* @ 5 g/kg seed + Profenophos @ 750 ml/ha etc. v/s farmer's practice.

The crop was sown in the month of November with a spacing of 30 cm x10 cm and the seed rate was 75-100 kg/ha. An entire dose of P through Diammonium Phosphate (DAP), K

through Muriate of Potash and Sulphur through bentonite sulphur was applied as basal during sowing. The seeds were treated with *Trichoderma viridae* @ 5 g/kg seeds then seeds were inoculated by *Rhizobium* and phospho-solubilizing bacteria biofertilizers each 5g/kg of seeds. Hand weeding was done once 30 days after sowing. One spray of Profenophos @ 750 ml/ha + ready mix combination of Carbendazim+ Mancozeb @ 2.5g/lit water was applied at 30 DAS. Fields were irrigated before to sowing and pre-flowering (35 DAS).
The crop was harvested from 20th March to 30th March during years of front line demonstrations. Farmer's practice constituted local variety with degenerated seed was used, the crop was sown between 10 to 20 October, broadcasting method of sowing, higher seed rate (150 kg/ha), imbalance dose of fertilizers applied (10 kg DAP/ha), no seed treatment, no biofertilizers, no hand weeding, no irrigation and no plant protection measures were adopted. The crop was harvested at the same time as harvesting of front line demonstration plots. Harvesting and threshing operations were done manually; 5m x 3m plot harvested in 3 locations in each demonstrations and average grain weight taken at 12% moisture level. A similar procedure was adopted on the Farmers Practices plot under each demonstration then grain weight converted into quintal per hectare (q/ha).
Before conducting the demonstrations trainings to farmers of respective villages were conducted concerning technological interventions. All other steps like site selection, farmers selection, the layout of demonstration, farmers participation etc. were followed as suggested by Choudhary, 1999 [9]. Visits of farmers and extension functionaries were organized at demonstration plots to disseminate the technology at a large scale. The data output was collected from both OFT & FLD plots as well as farmer's practices plot and finally the extension gap, technology gap, technology index along with the benefit- cost ratio were worked out (Samui *et al.*, 2000) [23] as given below:

Harvest index (%) = (Grain yield / Biological yield) × 100
% increase in yield = [{Demo yield – Farmers practices} / farmers practices} x 100
Technology gap = Potential yield – Demonstration yield
Extension gap = Demonstration yield – Farmers yield
Technology index = [(Potential yield - Demonstration yield)/ Potential yield] x 100
Additional cost in improved technology (Rs./ha) = Cost of improved technology (Rs/ha) - Cost of farmers practice (Rs./ha)

Additional returns (Rs/ha) = Net returns of improved technology (Rs./ha) - Net returns of farmers practice (Rs./ha)
Effective gain (Rs./ha) = Additional returns - Additional cost of improved technology

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

The techniques which were part of the package of practices were emphasized. However, it was left to the farmers to adopt and practice them depending on the individual farmer's resource availability and preference as to inputs (fertilizers and pesticides). Table 1 gives a comparison between the existing practice and those that were recommended.

Results and Discussion

Gap analysis of Recommended and Existing practices

The gap among the existing and recommended technologies of Chickpea crop in district Sidhi has been depicted in table-1. The full gap was observed in the case of use of HYVs, seed treatment, seed inoculation, weed management, plant protection and fertilizer application, while a partial gap was observed in seed rate, spacing, irrigation and field preparation, which definitely may be the reason of not achieving potential yield and demonstrated yield by farmer's practices. Farmers were not aware of recommended technologies. Farmers, in general, used degenerated seeds of local or old-age varieties instead of the recommended high yielding resistant varieties. Unavailability of seed in time & at the local level and lack of awareness were the main reasons for this gap in farmer's practices. Farmers applied higher a seed rate than the recommended and they were not using seed treatment techniques for the management of seed born diseases and also not aware of the application of micronutrients i.e., sulphur and zinc for enhancement of yield and quality of Chickpea because of lack of knowledge and interest. Sharma *et al.*, 2011 and Balai *et al.*, 2012 [26, 8] also reported that there is a technological gap between improved practices and existing practices.

Yield attributing characteristics

The yields attributing parameters like the number of pods/plant and harvest index (%) of Chickpea obtained over the years under recommended practice as well as farmers practice are depicted in Table 2. The Number of pods/plants of Chickpea ranged from 81.4 to 83.8 with a mean of 82.4 under recommended practice on farmer's fields as compared to range from 45.8 to 54.2 with a mean of 49.5 recorded under farmers practice. The higher values of the amount of pods/plant in recommended practice as compared to farmers practice was may be due to the use of high yielding varieties, integrated nutrient management -integrated pest management etc. (Singh *et al.*, 2021) [29].

Seed yield

The yield performance of recommended practices and farmers practices are depicted in Table 2. The data revealed that under the demonstration plot, the performance of Chickpea yield was found higher than that under farmers practice during consecutive years of demonstrations (2013-14 and 2018-19). The average yield of Chickpea under demonstration was recorded 9.99 and highest yield was observed 11.40 q/ha during 2017-18 over farmers practice 7.17 and 8.20 q/ha during the same year. The highest yield enhancement due to technological intervention was observed 42.6% over farmer's practice. The cumulative effect of the technological intervention of the six years,- revealed an average yield of 9.99 q/ha, 32.2% higher than farmers practice (7.17 q/ha). The year- to-year variations in yield can be explained based on variations in prevailing social, economic and climatic condition of the particular villages (Singh *et al.*, 2021 [29] and Singh *et al.*, 2022) [30].

Economic Parameter

Economic performances of Chickpea under on farm testing and front line demonstrations were depicted in table 3. The inputs and outputs prices of commodities prevailed during the years of demonstrations were taken for calculating cost of cultivation, net returns and benefit-cost ratio. The investment in production by adopting recommended practices ranged from Rs.12295 to 14280/ha with a mean value of Rs.13069/ha over the farmers practice Rs. 10480/ha to Rs. 11860 and average of Rs.11067/ ha during the demonstrations period. Cultivation of Chickpea under recommended practices gave a higher net return of Rs.20290 - Rs. 32800 compared to Rs.11430 - Rs. 21300/ha under farmers practice during 2013-14 to 2018-19. The average benefit-cost ratio of recommended practices was 2.91, varying from 2.62 to 3.30 during the study period and in farmers practice was 2.46, varying from 2.09 & 2.82. This may be due to higher yields obtained under recommended practices compared to farmer’s practices. Similar results have been reported earlier by Tomar, 2010, Patel *et al*., 2014 and Singh *et al.*, 2016 [32, 22, 17].

Technology gap, Extension gap and Technology Index

Technology Gap

The technology gap shows the gap in the demonstration yield over potential yield and the average technology gap was 8.02 qt/ha during the study period (Table 2). The trend of technology gap ranging between 6.60 and 9.60 qt/ha in 2013-2014 to 2018-2019, respectively and it reflects the farmers' cooperation in carrying out such demonstrations with encouraging results in subsequent years. The frontline demonstrations were laid down under the supervision of KVK Scientists at the farmer's field. The technology gap observed might be attributed to the dissimilarity in soil fertility status, local climatic situations, varietal suitability and adoption of technological practices. The technology gap implies researchable issues for the realization of potential yield, while the extension gap implies what can be achieved by the transfer of existing technologies. Mukharjee (2003) [20] have also opined that depending on identification and use of the farming situation, specific interventions may have greater implications in enhancing system productivity. Similar findings were also recorded by Katare *et al*. (2011) [15] and Singh *et al.*, 2022 [30].

Extension Gap

The extension gap is a parameter to know the yield differences between the demonstrated technology and farmer's practice and observed data was depicted in table 2. The extension gap ranged between 2.28 – 3.20 q/ha during the study period with an average of 2.82 q/ha which emphasized the need to educate the farmers through various means for the adoption of improved high yielding variety and improved agro technologies to reverse this trend of wide extension gap. More and more use of new HYV's by the farmers will subsequently change this alarming trend of developing extension gap. The new technologies will eventually lead the farmers to disenchantment discontinuance of old varieties with the new technology. The results are in agreement with research worker Patel *et al*., (2013) [21], who stated that, location-based problem identification and thereby specific interventions may have great implications in the enhancement of crop productivity.

Technology Index

The technology index showed the feasibility of the evolved technology at the farmer's fields. The higher technology index reflected the insufficient extension services for the transfer of technology. The lower value of the technology index shows the efficacy of the good performance of technological interventions. The average technology index was observed 44.5 per cent under front line demonstration (Table 2). The range of technology index was observed 36.7 to 53.3 per cent during the study period 2013-2014 to 2018-2019. The decreasing trend in the technology index shows that the farmer’s interest in adopting technology is increasing. This variation indicates that results differ according to soil fertility status, weather condition, non- availability of irrigation water and insect-pests attack in the crop. The results present study results agree with the findings of (Patel *et al*. 2014 [22], Singh *et al*. 2021 [29] & Singh *et al*. 2022) [30].

Table 1: Comparison between technological interventions and existing farmers practice of chickpea cultivation under front line demonstration programme

S No	Component	Technological intervention	Farmers practice	Gap (%)
1	Land preparation	Three ploughing	Three ploughing	No gap
2	Variety	JG 14	JG 315	Full gap
3	Seed rate	75-100 kg	120-130 kg	Partial gap
4	Seed treatment	Seed treatment was done with 2.5 gm of Carbendazim,1.5 g of Tibuconazole per kg seed for diseases and sucking pest and Trichoderma @ 5 g/kg seed to control wilt	No seed treatment	Full gap
5	Seed inoculation	Rhizobium and PSB culture with @20 gm/Kg seed	No seed inoculation	Full gap
6	Sowing method	Line sowing	Line sowing	No gap
7	Spacing	Row to row 30 cm and plant to plant 10 cm	Row to row 20 cm and plant to plant 10 cm	Partial gap
8	Fertilizer dose	25:50:25:20 (NPKS kg ha^{-1})	20 kg DAP^{-ha}	Full gap
9	Weed management	Application of Pendimethalin 30 EC 3 lit ha-1 as pre-emergence	No weed management	Full gap
10	Irrigation	Two irrigations at pre flowering and One irrigation Partial pod development stage	One irrigation at flowering stage	Partial gap
11	Plant protection	Bird percher (T-shaped pegs) @ 10/plot+ Emamectin Benzoate 5 SG @ 250 gm/ha for pod borer management.	No plant protection measures	Full gap

Table 2: Yield parameters, Yield, Technology gap, Extension gap and Technology index of chickpea as affected by recommended practices as well as farmer's practices

Year	Area (ha)	No. of farmers	Pods/plant		Grain yield (q/ha)			% increase over FP	Straw yield (q/ha)		Harvest index (%)		Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
			RP	FP	Pot.	RP	FP		RP	FP	RP	FP			
2013-14	4.0	10	83.2	45.8	18	9.38	6.26	33.3	15.34	12.35	37.9	33.6	8.62	3.12	47.9
2014-15	4.0	10	81.6	46.3	18	9.83	7.12	27.6	15.28	13.30	39.1	34.9	8.17	2.71	45.4
2015-16	4.0	10	82.2	48.3	18	8.40	6.12	27.1	14.56	12.42	36.6	33.0	9.60	2.28	53.3
2016-17	4.0	10	83.8	50.6	18	10.2	7.80	23.5	16.24	13.25	38.6	37.1	7.80	2.40	43.3
2017-18	4.0	10	82.3	51.8	18	11.4	8.20	39.0	17.36	14.23	39.6	36.6	6.60	3.20	36.7
2018-19	4.0	10	81.4	54.2	18	10.7	7.50	42.6	16.32	13.20	39.6	36.2	7.30	3.20	40.6
Total/ Average	24.0	60	82.4	49.5	18	9.99	7.17	32.2	15.85	13.13	38.6	35.2	8.02	2.82	44.5

Table 3: Effect of recommended practices as well as farmer's practices on economic parameters of chickpea cultivation

Year	Gross expenditure (Rs./ha)		Additional cost (Rs./ha)	Gross return (Rs./ha)		Net return (Rs./ha)		Additional returns (Rs./ha)	Effective gain (Rs./ha)	B:C Ratio	
	RP	FP		RP	FP	RP	FP			RP	FP
2013-14	12540	10480	2060	32830	21910	20290	11430	8860	6800	2.62	2.09
2014-15	12660	10560	2100	34405	24920	21745	14360	7385	5285	2.72	2.35
2015-16	12295	10560	1735	38640	28152	26345	17592	8753	7018	3.14	2.66
2016-17	13120	11240	1880	35700	27300	22580	16060	6520	4640	2.72	2.42
2017-18	13520	11860	1660	39900	28700	26380	16840	9540	7880	2.95	2.41
2018-19	14280	11700	2580	47080	33000	32800	21300	11500	8920	3.30	2.82
Average	13069	11067	2003	38093	27330	25023	16264	8760	6757	2.91	2.46

Conclusion

It is concluded from the study that through OFTs and FLDs of recommended technologies, yield of Chickpea can be increased to its potential yield in Sidhi district. This will substantially increase the income as well as livelihood of the farming communities. Major attention is to be made on development of area specific technology module for enhancing the productivity of pulses in various agro ecosystem of Madhya Pradesh.

References

1. Abbo S, Molina C, Jungma NNR, Grusa KA, Berkovitch Z, Reifen R *et al*. Quantitative trait loci governing carotenoid concentration and weight in seeds of chickpea (*Cicer arietinum* L.). Theor Appl Genet. 2005; 111:185–195
2. Anonymous. Annual Report. ICRISAT, Patancheru, Hyderabad, Telangana, 1996, 24-25p.
3. Anonymous. Directorate of economics and statistics, Krishi Bhavan, New Delhi, 2014.
4. Anonymous. Pulses Revolution-From Food to Nutritional Security. Ministry of Agriculture & Farmer Welfare (DAC&FW), Govt. India, 2018a, 1-115p.
5. Anonymous. Feeling the Pulse: Towards Better Self-Sufficiency in Pulses In India. ICRISAT Happening News Letter, 2018b.
6. Anonymous. Agricultural Statistics, Government of India. Ministry of Agriculture, Cooperative & Farmers Welfare, Krishi Bhavan, New Delhi-110 001, 2019.
7. Balikai RA, Biradar AP, Yelshetty S, Teggelli RG. Relative efficacy of some insecticides against chickpea pod borer, Helicoverpa armigera, Karnataka Journal of Agricultural Science. 2001; 14:346-348.
8. Balai CM, Meena RP, Meena BL, Bairwa RK. Impact of front-line demonstration on rapeseed mustard yield improvement. Indian Res. J. Ext. Edu. 2012; 12(2):113-116.
9. Choudhary BN. Krishi Vigyan Kendra-A guide for KVK mangers. Publication, Division of Agricultural Extension, ICAR, 1999, 73-78.
10. Choudhary AK, Yadav DS, Singh A. Technological and extension yield gaps in oilseeds in Mandi District of Himachal Pradesh. Indian J. Soil Conservation. 2009; 37(3):224–229.
11. Dhuppar P, Biyan S, Chintapalli B, Rao S. Chickpea Crop Production in the Context of Climate Change: An Appraisal. Indian Research Journal of Extension Education. 2012; 2:33-35.
12. Dubey S, Raghav RS, Singh P. Enhancement of productivity for chickpea (*Cicer arietinum* L.) through front line demonstration in farmer's fields. Legume Research. 2017; 40(2):335-337.
13. FAOSTAT, 2011. http://faostat.fao.org/
14. Gaur PM, Tripathi S, Gowada CLL, Rao CVR, Sharma HC, Pande S *et al*. Chickpea seed production manual. International Crop Research Institute for Semi Arid Tropics, 2010, 01p.
15. Katare, Subhash, Pandey SK, Mustafa M. Yield gap analysis of rapeseed-mustard through front line demonstrations. Agric. Update. 2011; 6:5-7.
16. Kumar S, Khar S, Sharma M, Singh P. Stability analysis for seed yield attributing traits in chickpea (Cicer arietinum) under Mid Hills of J&K. Legume Research. 2014; 37:552-555.
17. Kumar S, Singh P, Khar S, Sharma M. Variability association studies of screening of genotypes against pes seed born mosaic virus (psmv) in lentil. Lens culinaris under NW Himalayas of Jammu Kashmir. Legume Research. 2016; 39:26-30.
18. Mallikarjuna N, Sharma HC, Upadhyaya HD. Exploitation of wild relatives of pigeonpea and chickpea for resistance to Helicoverpa armigera. EJ SAT Agric Res Crop Improv. 2007; 3(1):4–7
19. Malhotra RS, Pundir RPS, Slinkard AE. Genetic resources of chickpea. In: Saxena MC, Singh KB (eds) The chickpea. CAB International Cambrian News Ltd,

Aberystwyth, 1987, 67–81p.
20. Mukharjee N. Participatory Learning and Action. Concept Publishing Company, New Delhi India, 2003, 63- 65p.
21. Patel MM, Jhajharia AK, Khadda BS, Patil LM. Frontline demonstration: An effective communication approach for dissemination of sustainable cotton production technology. Ind. J Extn. Edu. & R.D. 2013; 21:60-62.
22. Patel AK, Singh, Dhananjai, Baghel KS, Pandey AK. Enhancing Water Productivity to Improve Chickpea Production in Bansagar Command Area of Madhya Pradesh, Journal of Agri Search. 2014; 1(1):19-21
23. Samui SK, Maitra S, Roy DK, Mandal AK, Saha D. Evaluation on front line demonstration on groundnut. J Indian Soc Costal Agric Res. 2000; 18:180-183
24. Saraf CS, Rupela OP, Hegde DM, Yadav RL, Shivkumar BG, Bhattarai S *et al*. Biological nitrogen fi xation and residual effects of winter grain legumes in rice and wheat cropping systems of the Indo-Gangetic plain. In: Kumar JVDK, Johansen C, Rego TJ (eds) Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic plain. Oxford/IBH Publishing, New Delhi, 1998, 14–30p.
25. Saxena MC. Problems and potential of chickpea production in nineties. In: Chickpea in the nineties: proceedings of the second international workshop on chickpea improvement, 4–8 Dec 1989, ICRISAT Center, Patancheru, India, 1990.
26. Sharma AK, Kumar V, Jha SK, Sachan RC. Front line demonstrations on Indian mustard: An assessment. Indian Res. J. Ext. Edu. 2011; 11(3):25-31.
27. Singh KB. Chickpea (*Cicer arietinum* L.). Field Crops Res. 1997; 53:161–170
28. Singh, Dhananjai, Patel AK, Singh SK, Baghel MS. Increasing the Productivity and Profitability of Paddy through Front Line Demonstrations in Irrigated Agro Ecosystem of Kaymore Plateau and Satpura Hills. Journal of Agri Search. 2016; 3(3):161-164
29. Singh Dhananjai, Patel AK, Chouksey Priya, Tiwari Amrita, Baghel MS. Impact assessment of front line demonstrations on sesame (*Sesamum indicum* L.) in Sidhi district of Madhya Pradesh. International Journal of Tropical Agriculture. 2021; 39(1-2):23-27
30. Singh Dhananjai, Jharia Pushpa, Tiwari Amrita, Patel AK, Baghel MS. Assessment of productivity and profitability of pigeon pea var. TJT 501 through cluster front line demonstration in Sidhi district of Madhya Pradesh. The Pharma Innovation Journal. 2022; 11(1):523-526
31. Tiwari AK, Shivhare AK. Pulse in India: Retrospect and prospects. Government of India, Ministry of Agriculture & Farmers Welfare (Department of Agriculture, Cooperative and Farmers Welfare) Directorate of Pulses Development, Vindhyachal Bhavan, Bhopal (M.P.) 462004. DPD/Pub.1/Vol.2/2016, 2017.
32. Tomar RKS. Maximization of productivity for chickpea through improved technologies in farmer’s field. Indian Journal of Natural Products and Resources. 2010; 1(4):515-517.
33. Varshney RK, Song C, Saxena RK, Azam S, Yu S, Sharpe AG *et al*. Draft genome sequence of chickpea (Cicer arietinum) provides a resource for trait improvement. Nat Biotechnol. Epub January 27. Available from: http://www.nature.com/nbt/journal/vaop/ncurrent/full/nbt.2491.html, 2013.
34. Williams PC, Singh U. Nutritional quality and the evaluation of quality in breeding programmes. In: Saxena MC, Singh KB (eds) The chickpea. CAB International, Wallingford, 1987, 329–390p.
35. Zohary D, Hopf M. Pulses. In: Domestication of plants in the old world: the origin and spread of cultivated plants in West Asia, Europe, and the Nile Valley, 3rd edn. Oxford University Press, New York, 2000, 108–111p.