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Technological Options on Yield Gap Analysis, Economics, Adoption and Horizontal Spread of Pulse Crops

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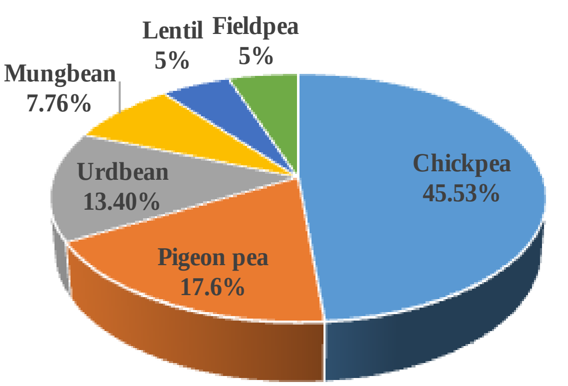
A B S T R A C T

Cluster frontline demonstration (CFLDs) is one of the key extension tools for transfer of technology at grass root level that directly impact the horizontal spread of technology. Pulses play an important role in the food and farming economy of our country. Considering their limited input requirements, soil enriching properties and suitability for growing in areas where moisture (water) is limited, pulses occupy a unique place in our agriculture system. The area, production and productivity of pulses of Uttar Pradesh and in district Gorakhpur is also quite low as compare to other states, national acreage and production. Among various constraints, poor crop management and protection technologies assume primary position for considering the facts of low yield of pulse crops. Under centrally sponsored scheme on pulses production technology under NFSM scheme, the Mahayogi Gorakhnath Krishi Vigyan Kendra, Gorakhpur conducted 175 and 35 demonstrations on pigeon pea and chickpea during 2017-18 and 2018-19 respectively. The critical inputs were identified in existing production technology through farmers meetings and group discussion. The findings in respect of pigeon pea and chickpea overall yield trend of demonstrations ranged from 12.77 to 17.32 q/ha and 17.56 to 19.23 q/ha and yield increase ranged from 36.70 to 42.55 per cent and 42.67 to 57.91 per cent over the local practices yield, respectively. The yield levels were considerably lower under local practices because of considerable variation in the extent of adoption of recommended technology depending upon the amount of risk involved in terms of cost, convenience, skill and knowledge about the concerned practice. Average extension gap, technology gap and technology index of pigeon pea and chickpea were found 4.07, 10.66 q/ha and 42.64 per cent and 5.87, 6.45 q/ha and 26.85 per cent, respectively. Average gross returns and net returns of demonstration in pigeon pea and chickpea crops were 39.63 and 57.42 per cent and 56.57 and 88.28 per cent higher than the farmers' practices respectively. Average benefit cost ratio was found higher throughout the study in pigeon pea and chickpea i.e. 3.47 and 3.27 respectively. The overall adoption level of pigeon pea and chickpea production technology were increased by 211.46 and 285.76 per cent respectively, due to CFLDs. The varieties of pigeon pea such as NA 1 and local (old and mix variety) were replaced by NA 2 and local old mixed variety of chickpea was replaced by GNG 1581 in cluster demonstration. In present study efforts were also made to study the impact of CFLDs on horizontal spread of variety of different pulse crops viz. pigeon pea and chickpea which was increased 462.50% and 366.67%, respectively, if appropriate package and practices are followed.

Introduction

Pulses are the staple source of protein to the majority of Indian population and contribute significantly to the nutritional security of the country. Moreover, pulses offer soil maintenance benefits through biological nitrogen fixation, which improves yields of cereals and nutrient exhaustive crops through crop rotation and can also result in saving for smallholder farmers from less fertilizer use. Besides these, they also supply additional fodder for cattle, which improve their health and milk production.

India is producing 25.23 million tons of pulses from an area of 29.99 million hectares which is one of the largest pulses producing countries in the world. It has been estimated that India's population would reach 1.68 billion by 2030 from the present level of 1.21 billion. Accordingly, the projected pulse requirement for the year 2030 is 32 million tonnes with an anticipated required growth rate of 4.2% (IIPR Vision 2030). Thus, there is need to increase production and productivity of pulses in the country by more intensive interventions. To achieve target of additional production of pulses, it is necessary to make efforts on important pulse crops depending upon their contribution in national productivity.



Total pulses production shares in India (DES.2018)

The production share of important pulse crops are Chickpea (45.53 per cent), Pigeon pea (17.06 per cent), Urdbean (13.40 per cent), Mungbean (7.76 per cent), Lentil (5 per cent) and Field pea (5 per cent). Major areas under pulses are in the States of Madhya Pradesh (33 per cent), Maharashtra (13 per cent), Rajasthan (12 per cent), Uttar Pradesh (9 per cent), Karnataka (8 per cent), Andhra Pradesh (5 per cent), Gujrat (4 per cent), Jharkhand (3 per cent), Tamilnadu, (2 per cent), Telangana (2 per cent) and which together for about 91 per cent of the total production (DES, 2018).

The average productivity of country is about 841 kg/ha against the average global productivity of 1023 kg/ha (DES, 2018). The average productivity of pulses in the states Uttar Pradesh producing about 974 kg/ha in 2017-18 (Pocket Book of Agricultural Statistics, 2018). The area, production and productivity of pulses of Uttar Pradesh and in district Gorakhpur is also quite low as compare to other states, national acreage and production. The cause of low productivity of pulses is due to use of old varieties, higher seed rate and broadcasting method of sowing and biotic/abiotic stresses in the district. Thus, there is need to create awareness among the farming community to popularize the location specific improved varieties to increase the production and productivity of pulse crops in the district. In view of this, an intensive intervention such as cluster front-line demonstrations was conducted to introduce and disseminate improved varieties of pulse crops to increase the crop yield during 2017-18 to 2018-19. Thus, the present manuscript deals with the yield enhancement of improved varieties of pulse crops along with yield gaps, technology adoption and horizontal spread at farmer's fields.

Materials and Methods

Gorakhpur comes under North Eastern Plain Zone of Uttar Pradesh and agriculturally it is very important district. The Mahayogi Gorakhnath Krishi Vigyan Kendra were conducted cluster frontline demonstrations (CFLDs) under National Food Security Mission scheme during *kharif* and *rabi* seasons of year 2017-18 to 2018-19. The Krishi Vigyan Kendra had organized 175 CFLDs on pigeon pea and 35 CFLDs on chickpea in the six blocks of Gorakhpur district viz., Jungle Kaudiya, Campierganj, Pali, Bhathat, Chargawan and Khorabar. The total area of 70 ha and 12.15 ha was covered for the pigeon pea and chickpea demonstrations, respectively. An extensive survey was made before conducting the cluster frontline demonstrations to find out the need-based farmers. The receptive and innovative farmers were selected through group meeting in each year and taking in to consideration mainly the approachable site and adaptive attitude of the farmers. Specific skill training was imparted to the selected farmers regarding different aspects of agro-techniques for higher productivity of pulse crops. The area under each CFLD's was kept in one acre and the traditional practices were taken as a control. Field days were also conducted at crop maturity stage in each cluster to show the results of frontline demonstration to the farmers of the same village and neighbouring villages of farmers for horizontal spread of technologies.

All critical inputs *viz.* improved varieties of pigeon pea and chickpea that was NA 2 and GNG 1581 respectively and demonstrated with full package of practices i.e. proper tillage, proper seed rate, time of sowing and sowing method, balanced dose of fertilizer (18 kg Nitrogen 46 kg P_2O_5/ha), *Trichoderma* and *Rhizobium* culture @ 5 gm/kg of seed as seed treatment, proper irrigation, weed management and improved plant protection measure were applied (Table 1) at farmers' fields.

The demonstration plot was supervised by the KVK scientists. The data related to yield and cost particulars were collected KVK scientists separately from CFLDs and farmers practice. However, data about adoption and horizontal spread of technologies were collected from the farmers with help of interview schedule. The average prices of inputs and outputs commodities prevailed during each year of demonstrations were taken for calculating cost of cultivation, net return and benefit cost ratio.

Yield parameters of both demonstrations and check involving farmers practices were recorded. The technology gap, extension gap and technology index were calculated as suggested by Samui *et al.*, (2000) and Dayanand *et al.*, 2012.

$$\text{(A) Impact on yield (\%)} = \frac{Dy - Fpy}{Fpy} \times 100$$

Where,
Dy= Demonstrated yield
Fpy=Farmer practice yield

(B) Extension gap= Dy - Fpy

(C) Technology gap
= Potential Yield (Py) - Demonstrated Yield (Dy)

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

(E) Additional cost in improved technology (Rs/ha)=Cit - Cfp

Where
Cit=Cost of improved technology (Rs/ha)
Cfp=Cost of farmers practice (Rs/ha)

(F) Additional returns (Rs/ha) = Nrit - Nrfp

Where,
Nrit = Net returns of improved technology (Rs/ha)
Nrfp =Net returns of farmers practice (Rs/ha)

(G) Effective gain (Rs/ha)= Arit - Acit

Where,
Arit=Additional returns of improved technology (Rs/ha)
Acit=Additional cost of improved technology (Rs/ha)

$$\text{(H) Benefit cost ratio (BCR)} = \frac{\text{Gross return (Rs/ha)}}{\text{Gross expenditure (Rs/ha)}}$$

The yield gap was also comprising at least two components i.e. Yield gap I and Yield gap II (Mondal, 2011). Yield Gap I refer to the difference between potential yield and farm yield obtained at demonstration plots, while Yield Gap II, reflecting the effects of biophysical and socio-economic constraints, was the difference between yield obtained at the demonstration plot and actual yield obtained on farmers' fields. The yield gaps (Table 3) were estimated as follows:

Yield Gap I= $[(Y_P - Y_D)/Y_P]x100$
Yield Gap II= $[(Y_D - Y_F)/Y_D]\ 100$

where,
Y_P is the potential yield
Y_D is the demonstration plot yield
Y_F is the existing farmers yield

However, data about adoption and horizontal spread of technologies were collected from the farmers with the help interview schedule. Data were subjected to suitable statistical methods. The following formulae were used to assess the impact on different parameters of pulse crops.

$$\text{Impact on Yield (\% Change)} = \frac{YD_p - YC_p}{YC_p} \times 100$$

Where,
YD_p= Yield of demonstrated plot
YC_p= Yield of control plot

$$\text{Impact on Adoption (\% Change)} = \frac{A_{ad} - A_{bd}}{A_{bd}} \times 100$$

Where,

A_{ad} =No. of Adopters after demonstration
A_{bd}=No. of Adopters before demonstration

$$\text{Impact on Horizontal spread (\% change)} = \frac{A_{iad}\text{ (ha)} - A_{bd}\text{ (ha)}}{A_{bd}\text{ (ha)}} \times 100$$

Where,

A_{iad}= Area increased after demonstration
A_{bd}= Area before demonstration

Results and Discussion

Impact of CFLDs on yield of pulse crops

The findings of impact of cluster frontline demonstrations (CFLDs) on yield enhancement of different pulse crops are presented hereunder. It is evident from table 1 that the average yield was 14.34 q/ha and 17.56 q/ha in pigeon pea and chickpea demonstrated plots respectively as well as control plot was 10.27 q/ha and 11.69 q/ha, respectively. This showed that there was a positive and significant increase in the average crop wise yield of pigeon pea and chickpea demonstration plots over the farmers practice by 39.63 and 50.29 per cent respectively. The increase in percentage of yield was ranging between 36.70-42.55 in pigeon pea and 42.67-57.91 in chickpea during the demonstration period. The results clearly speak of the positive effect of frontline demonstration over existing practice towards enhanced the yield of pulses in demonstrated area. The similar trends of yield enhancement in front line demonstration of pulse crops has been documented by Dwivedi, *et al.*, 2013.

The demonstrated technology of pigeon pea yielded average productivity by 146.99, 31.68 and 67.66 per cent more over district, state and national yield, respectively (Fig. 1). The demonstrated technology of chickpea gave average productivity by 39.74, 44.56 and

74.71 per cent more over district, state and national yield, respectively (Fig. 2). Singh *et al.*, (2015) also reported similar findings in chickpea crop under crop cafeteria during 2014-15 crop seasons.

Technology gap

The difference between potential yield and demonstration plots yield was 10.66 and 6.45 q/ha in pigeon pea and chickpea, respectively during demonstration period (Table 1). The average technology gap under two-year CFLDs in pulse crops programme was observed as 8.56 q/ha. It indicates that still there is gap in technology demonstration as a result of which the potential yield of the improved practices could not be reaped by the participating farmers. This may be due to the soil fertility, managerial skills of individual farmer's and climatic condition of the area. Hence, location specific recommendations are necessary to bridge these gaps. The findings are in line with that reported by Vijaya Lakshmi *et al.,* (2017).

Extensions gap

Extensions gap were observed as 4.07 and 5.87q/ha for pigeon pea and chickpea, respectively during demonstration period (Table 1). The average extension gap under two-year CFLDs in pulse crops programme was recorded as 4.97 q/ha in this study and it should be filled by various extension methods. This emphasized the need to educate the farmers through various techniques for the adoption of improved agricultural production technologies to reverse this trend of wide extension gap. More and more use of latest production technologies with high yielding variety will subsequently change this alarming trend of galloping extension gap. This finding is in corroboration with the findings of Joshi *et al.,* 2014, Kumar *et al.*, 2014 and Kulkarni *et al.,* (2018).

Technology index

The technology index shows the feasibility of the demonstrated technology at the farmer's field. The average technology index was observed 42.64 per cent in pigeon pea and 26.85 percent in chickpea (Table 1). On an average technology index of 34.75 per cent was observed during the two-years of CFLDs programme, which shows the effectiveness of technical interventions. This accelerates the adoption of demonstrated technological interventions to increase the yield performance of pulse crops. This variation also indicates that the result differs according soil fertility status, weather condition and mismanagement of crop. With adoption of improved practices, the technology gap can be reduced as a result technology index will be reduced. Similar findings were reported by Joshi *et al.,* 2014 and Kumar *et al.*, 2014.

Impact of CFLDs on pulse crops in relation to yield gap

Yield gaps in crops are real and the challenge needs to be addressed in the interest of increased and sustainable crop production. Based on these data, the yield gaps between potential and achievable yields (YG I), between achievable and farmers' yields (YG II) and total yield gaps between potential and farmers' yields were estimated (Table 2). The average yield gap I and II was recorded 45.79 and 28.35 per cent respectively in pigeon pea crop and it was 26.86 and 33.29 per cent in chickpea crop, respectively. This finding is in corroboration with the findings of Mondal, 2011 and Sultana *et al.*, 2019. Yield gap of different crops (Fig. 3) was also analyzed with average yield of district, state and national are depicted in table 2 that wide yield gap was observed in pigeon pea and chickpea crops during study period. It is emphasized the need to educate the farmers through various means for the adoption of improved production and protection technologies to reverse this trend of wide yield gap. More and more use of latest production technologies with high yielding varieties and integrated plant protection components will subsequently change this alarming trend of galloping yield gap. This finding is in corroboration with the findings of Singh *et al.,* 2012 and Raj *et al.,* 2013. The possibility of increasing yield of pigeon pea and chickpea per unit area was found in the area at significant level. It may be due to genetic variability of varieties with optimum seed rate, seed treatment, spacing with optimum plant stand, optimum fertilizer application, need based plant protection, proper weed management and local climatic situation. The huge variation in yield was due to varietal characteristics and changes in weather (erratic rainfall) during cropping period. Thus, there are bright chances to increase the sustainable productivity of these crops by adopting improved technologies with proper plant protection management.

Impact of CFLDs on economics of pulse crops

The economics of pulse crops production under cluster frontline demonstration were estimated and the results have been presented in Table 3. Different variables like high yielding varieties seed, fertilizers, bio-fungicide, bio-insecticide and chemical pesticides etc. were considered as a technological intervention. On an average an additional investment of Rs. 1930/ha and Rs. 2939/ha was made under demonstration of pulses for pigeon pea and chickpea, respectively. The average cost of cultivation increased by 10.26% and 15.79 % in pigeon pea and chickpea respectively with improved technological interventions as compared to farmers practice. The comparative profitability of different pulse crops also revealed that among them chickpea produced maximum average gross monetary return i.e. Rs. 73610/ha followed by pigeon pea Rs. 71700/ha. The average net returns of demonstration for pigeon pea was Rs. 50976.50/ha as compare to farmers practices of Rs. 32556.50/ha whereas in chickpea average net return was Rs. 50994.50/ha as compared to farmers practice of Rs.27083.50/ha. The study found average additional net returns of Rs. 18420/ha and Rs. 23911/ha from the demonstrated plots of pigeon pea and chickpea respectively, which might be due to differences in cost of cultivation and higher market price. In consequence, average gross monetary return increased by 39.63% and 57.43% in pigeon pea and chickpea crops respectively indicating the importance of improved technologies. The higher gross monetary return realized by the farmers indicate the economic feasibility of the technology. The data presented in Table 5 also revealed the expenditure involved in the demonstrated plot is higher than the farmers' field due to additional cost of cultivation but the yield obtained is also higher in the demonstrated plot that is confirmed by the comparative result obtained by calculating the cost benefit ratio.The effective gain was received as Rs. 16390/ha and Rs. 20972/ha from pigeon pea and chickpea, respectively whereas average benefit cost ratio was recorded by 3.47 and 3.27 from demonstration plots of pigeon pea and chickpea respectively while it was received by 2.78 and 2.42 from farmers practice. Similar findings were also reported in frontline demonstrations on pulse crops by Lathwal (2010) and Dwivedi *et al.,* (2014).

Impact of CFLDs on adoption of pigeon pea production technologies

Impact of cluster frontline demonstrations on adoption of pigeon pea production technology by the farmers is depicted in table 4. It was found that adoption of recommended varieties of pigeon pea (NA 2) by the farmers was less before demonstration period which was increased by 581.81 per cent after demonstration. This was followed by adoption of important operation of pigeon pea i.e. recommended weed management practices which was increased significantly by 314.29 per cent followed by recommended dose of fertilizer (311.11 per cent) and plant protection measure (290.48 per cent). Seed treatment with *Trichoderma* powder and *Rhizobium* culture @ 5 g/kg seed was increased by 193.33 per cent. It was also found that a number of adopters for land preparation and application of FYM in pigeon pea were 88.57% before demonstrations, which increased to 100.00% after cluster frontline demonstrations in selected villages. The overall adoption level of pigeon pea production technology was increased by 211.46 per cent due to CFLDs organized by KVK, Gorakhpur. The present study is in line with Patil *et al.*, (2018).

Impact of CFLDs on adoption of chickpea production technologies

Data on adoption of chickpea production technologies by the beneficiary farmers are presented in table 5. The CFLDs made a significant impact on the adoption of recommended varieties GNG 1581of chickpea crop in the study area. Before the cluster frontline demonstrations, 25.71% farmers in adopted villages had used old mix and small seeded varieties, however, they shifted to improved chickpea variety GNG 1581 (233.33%) after exposure to the demonstrations. The number of adopters for land preparation and application of FYM were raised from 51.43 to 91.43%, use of recommended seed rate from 17.14 to 88.57% and fertilizer management from 11.43 to 85.71% in CFLDs. In other words, CFLDs made a positive impact on the adoption of seed treatment with *Trichoderma* powder and *Rhizobium* culture @ 5 g/kg seed (380%), land preparation and application of FYM (77.78%), weed management (109.09%), use of recommended seed rate (416.67%), fertilizer management (650%), sowing methods (225%), time of sowing (180%) and plant protection measure (300%). In all, CFLDs had created 285.76% change in the adoption of recommended chickpea production technologies in the selected villages. Most of the farmers in selected villages were marginal and small holders, cultivating chickpea as subsistence pulse crop and unaware about improved pulse crops technologies. But after exposure to cluster frontline demonstrations, they were motivated to use improved varieties and realized the potential of chickpea crop. These results are in close conformity with the findings recorded in the case of oilseed crops (Patil, *et al.*, 2018).

Impact of CFLDs on varietal replacement of pulse crops

The CFLDs are proven extension intervention for changing existing/traditional practice of farmers. Therefore, efforts were made to know the varietal replacement in selected cluster due to CFLDs and data depicted in table 6. It was found that the previously grown varieties of pigeon pea such as old and mix variety Narendra Arhar 1, and in chickpea Pusa 372 and ‘Local’ were replaced by improved variety of pigeon pea as NA 2 and chickpea as GNG on a large scale in selected villages. The CFLDs beneficiary farmers had received a good yield in demonstration plots by the adoption of improved varieties of these pulse crops.

Therefore, they have motivated and continued the adoption of improved varieties of pulse crops on a large scale for succeeding years. This finding is in corroboration with the findings of Patil *et al.*, (2018).

Table.1 Gap in grain yield production of pulse crops under cluster front line demonstration (C-FLD)

Name of crop	Year	Technology demonstrated	Potential yield of variety (q/ha)	Under C-FLD programme		Average yield (qt/ha)		Impact (% change)	TG (q/ha)	EG (q/ha)	TI (%)
				No. of Demo.	Area (ha)	*DP	FP				
Pigeon pea (Kharif)	2017-18	Narendra arhar-2 + seed treatment with carbendazim @ 2g/kg seed + Rhizobium culture @ 200g/10 kg seed + Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + One hand weeding at 45-60 DAS + Indoxacarb 15.8% E.C. @ 500 ml/ha at 50% flowering and pod filling stage	25	50	20.00	14.64 (12.44-16.23)	10.27	+42.55	10.36	4.37	41.44
	2018-19	Narendra arhar-2 + seed treatment with carbendazim @ 2g/kg seed + Rhizobium culture @ 200g/10 kg seed + Imazethapyr 10%SL @1 lt /ha at @ 25 DAS + Emamectin benzoate 5% SG @220g/ha at 50% flowering and pod filling stage	25	125	50.00	14.04 (13.10-18.40)	10.27	+36.70	10.96	3.77	43.84
Total/Average				**175**	**70.00**	**14.34 (12.77-17.32)**	**10.27**	**+39.63**	**10.66**	**4.07**	**42.64**
Chickpea (Rabi)	2017-18	GNG 1581+ Seed treatment with carbendazim @ 2g/kg seed + PSB culture @ 5gm/kg seed + One hand weeding at 60 days after sowing/Emamectin benzoate 5% SG @220g/ha at 50% flowering and pod filling stage	24	10	2.15	16.95 (15.65-18.30)	11.88	+42.67	7.05	5.07	29.36
	2018-19	GNG 1581 + seed treatment with Trichoderma @ 5 g/kg seed + Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + One hand weeding at 60 DAS + Neem oil 0.15% @ 2 ml/lit. of water at 50% flowering + Emamectin benzoate 5% SG @220g/ha at 50% pod filling stage	24	25	10.00	18.16 (16.80-20.60)	11.50	+57.91	5.84	6.66	24.33
Total/Average				**35**	**12.15**	**17.56 (16.23-19.45)**	**11.69**	**+50.29**	**6.45**	**5.87**	**26.85**
Overall Total/Average				**210**	**72.15**	**15.95**	**10.98**	**+44.96**	**8.56**	**4.97**	**34.75**

Demo.= Demonstration; DP= Demonstrated Plot; FP= Farmers' practice; TG= Technology gap; EG= Extension gap; TI= Technology index
* Figures in parentheses indicate lowest and highest yield of demonstrated farmer

Table.2 Impact of CFLDs on pulse crops in relation to yield gap during 2017-18 to 2018-19

SN	Crop name	Yield gap (q/ha) as compared to						Yield gap I (%)		Yield gap II (%)	
		District level		State level		National level					
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
1.	Pigeon pea	9.24	7.74	2.84	3.96	5.04	6.36	41.71	49.86	29.85	26.85
	Mean	**(8.49)**		**(3.40)**		**(5.70)**		**(45.79)**		**(28.35)**	
2.	Chickpea	6.25	3.16	5.35	5.46	6.32	8.60	29.38	29.91	24.33	36.67
	Mean	**(4.71)**		**(5.41)**		**(7.47)**		**(26.86)**		**(33.29)**	

Table.3 Impact of CFLDs on Economics of pulse crops

Crops	Year	CoC (Rs/ha)		CoC increase over FP (%)	GMR (Rs/ha)		GMR increase over FP (%)	NR (Rs/ha)		NR increase over FP (%)	ACoC in IT (Rs/ha)	ANR (Rs/ha)	BCR		Effective gain (Rs/ha)
		IT	FP		IT	FP		IT	FP				IT	FP	
Pigeon pea	2017-18	20192	18537	8.93	73200	51350	42.55	53008	32813	61.55	1655	20195	3.63	2.77	18540
	2018-19	21255	19050	11.58	70200	51350	36.71	48945	32300	51.53	2205	16645	3.30	2.78	14240
	Average	**20723.50**	**18793.50**	**10.26**	**71700**	**51350**	**39.63**	**50976.50**	**32556.50**	**56.54**	**1930**	**18420**	**3.47**	**2.78**	**16390**
Chick pea	2017-18	21171	17253	22.71	74580	47520	56.94	53409	30267	76.46	3918	23142	3.52	2.75	19224
	2018-19	24060	22100	8.87	72640	46000	57.91	48580	23900	103.26	1960	24680	3.02	2.08	22720
	Average	**22615.50**	**19676.50**	**15.79**	**73610**	**46760**	**57.43**	**50994.50**	**27083.50**	**89.86**	**2939**	**23911**	**3.27**	**2.42**	**20972**

CoC= Cost of cultivation; IT= improved technological interventions; FP= Farmers' practice GMR= Gross monetary returns; ACoC= Additional cost of cultivation; NR= Net Returns; ANR= Additional net returns; BCR= Benefit cost ratio.

Table.4 Impact of CFLDs on adoption of Pigeon pea production technology

Technology	No. of adopters (N=175)		Change in No. of Adopter	Impact (% Change)
	*Before demonstration	*After demonstration		
Land preparation and FYM application	155 (88.57)	175 (100.00)	+20	12.90
Recommended Varieties (NA 1 & 2, IPA 203)	22 (12.57)	150 (85.71)	+128	581.81
Seed rate (15 Kg/ha)	112 (64.00)	159 (90.86)	+47	41.96
Seed treatment (*Trichoderma* powder and *Rhizobium* culture @ 5 g/kg seed)	45 (25.71)	132 (75.43)	+87	193.33
Time of sowing (First fortnight of June to first fortnight of July)	138 (78.86)	168 (96.00)	+30	21.74
Recommended sowing method (line sowing raised bed 60 x 15cm (R x P)	45 (25.71)	106 (60.57)	+61	135.56
Fertilizer dose (18 N and 46 P_2O^5 Kg/ha)	36 (20.57)	148 (84.57)	+112	311.11
Recommended weed management (Pendimethalin 30% EC @ 3.3 lit./ha as pre- emergence + One hand weeding at 45-60 days after sowing/ Imazethapyr 10%SL @1 lt /ha at @ 25 DAS)	28 (16.00)	116 (66.29)	+88	314.29
Need based Plant protection measure (Ist spray of Neem oil 0.15% @ 2-3 ml/litre of water at 50% flowering and 2nd spray of Emamectin benzoate 5% SG @ 0.4 g/litre of water at 50% pod filling stage	42 (24.00)	164 (93.71)	+122	290.48
			Overall Impact	**211.46**

* Figures in parentheses indicate percentage, Source: Field survey of 2019-20

Table.5 Impact of CFLDs on adoption of Chickpea production technology

Technology	No. of adopters (N=35)		Change in No. of Adopter	Impact (% Change)
	*Before demonstration	*After demonstration		
Land preparation and FYM application	18 (51.43)	32 (91.43)	+14	77.78
Recommended Varieties (GNG 1581, RSG 963, JAKI 9218)	9 (25.71)	30 (85.71)	+21	233.33
Seed rate (80 Kg/ha)	6 (17.14)	31 (88.57)	+25	416.67
Seed treatment (*Trichoderma* powder and *Rhizobium* culture @ 5 g/kg seed)	5 (14.29)	24 (68.57)	+19	380.00
Time of sowing (Second fortnight of October to first fortnight of November)	10 (28.57)	28 (80.00)	+18	180.00
Recommended sowing method (line sowing 30x10cm (R x P)	8 (22.86)	26 (74.23)	+22	225.00
Fertilizer dose (18 N and 46 P_2O^5 Kg/ha)	4 (11.43)	30 (85.71)	+26	650.00
Recommended weed management (Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + One hand weeding at 60 days after sowing)	11 (31.43)	23 (65.71)	+12	109.09
Need based Plant protection measure (Ist spray of Neem oil 0.15% @ 2-3 ml/litre of water at 50% flowering and 2nd spray of Emamectin benzoate 5% SG @ 0.4 g/litre of water at 50% pod filling stage	7 (20.00)	28 (80.00)	+21	300.00
			Overall Impact	**285.76**

* Figures in parentheses indicate percentage Source: Field survey of 2019-20

Table.6 Impact of CFLDs on varietal replacement of pulse crops

Crop	Previous grown variety	Variety introduced
Pigeon pea	Old and mix variety Narendra Arhar 1	Narendra Arhar 2
Chickpea	Old mix and small seeded variety Pusa 372	GNG 1581

Source: Field survey of 2019-20

Table.7 Impact of CFLDs on horizontal spread of variety of different pulse crops

Crop	Area (ha)		Change in Area (ha)	Impact (% change)
	Before demonstration	After demonstration		
Pigeon pea Variety Narendra Arhar 2	8.00	45.00	+37.00	462.50
Chickpea GNG 1581	15.00	70.00	+55.00	366.67

Source: Field survey of 2019-20

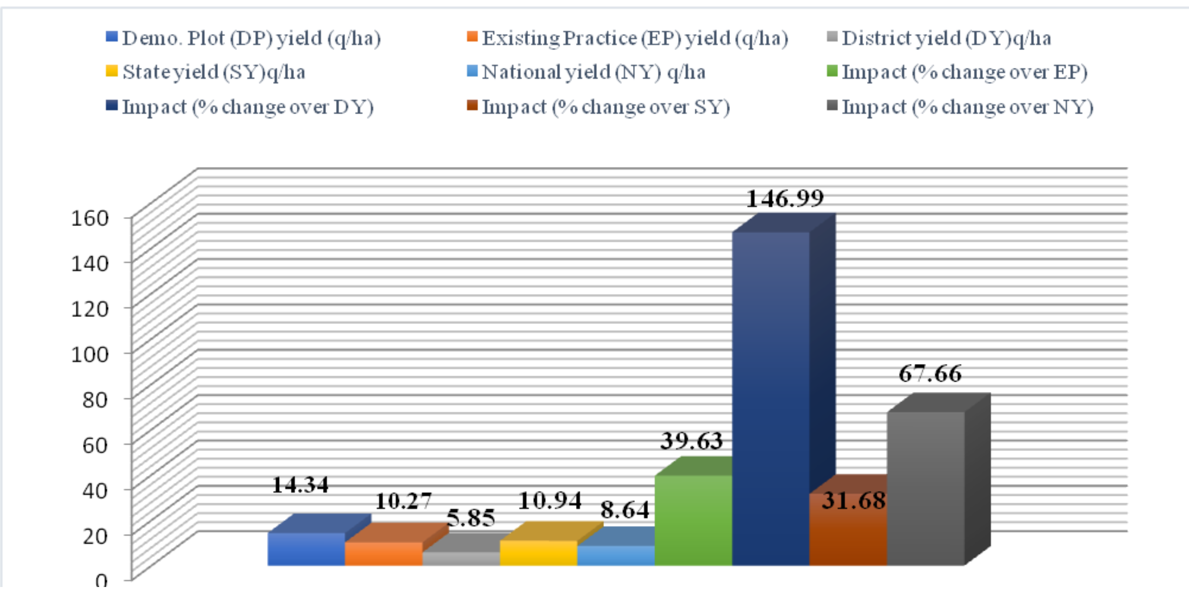


Fig.1 Impact of technological interventions on sustainable productivity of pigeon pea crop

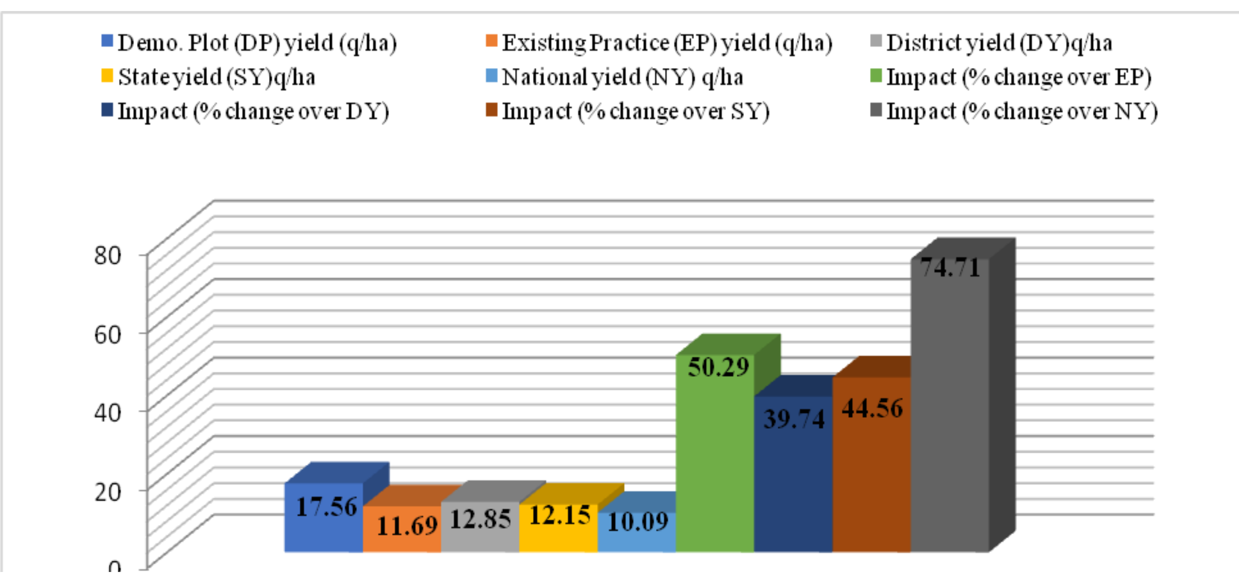


Fig.2 Impact of technological interventions on sustainable productivity of chickpea crop

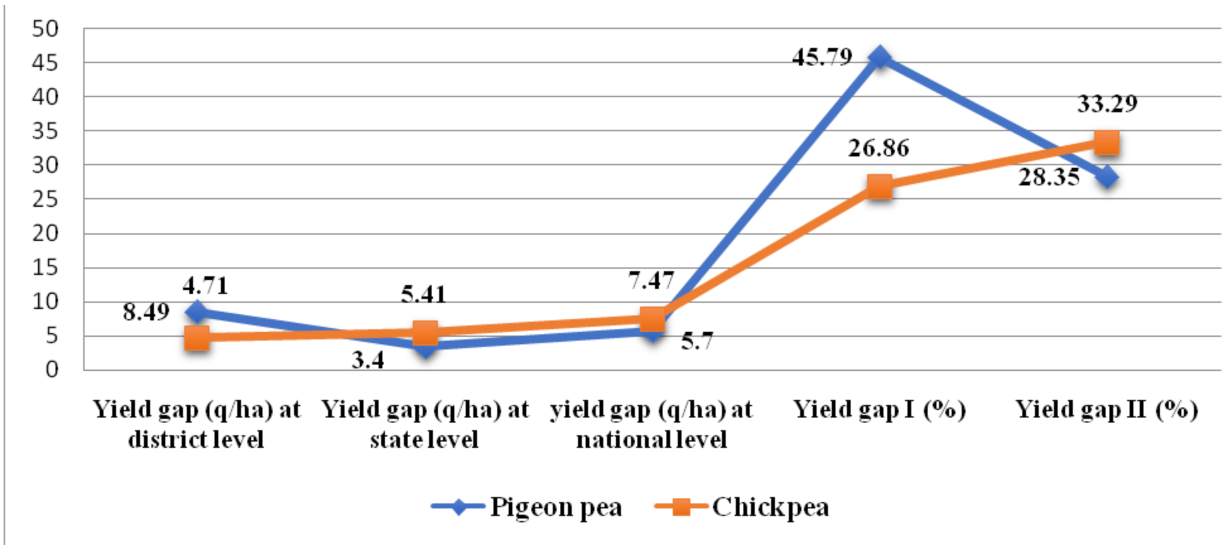


Fig.3 Impact of technological interventions on pulse crops in relation to yield gap (q/ha)

Impact of CFLDs on horizontal spread of different varieties of pulse crops

In the present study, efforts were made to study the impact of CFLDs on the horizontal spread of different varieties of pulse crops. It was evident from table 7 that CFLDs organized on pulse crops helped to increase the area under improved varieties in selected villages. There was a significant increase in area from 8.00 to 45.00 ha under pigeon pea variety NA 2 (increased up to 462.50%) and from 15.00 to 70.00 ha under chickpea variety GNG 1581 (increased up to 366.67%) in CFLDs programme. The reasons might be their agronomical attributes such as high yielding nature, wilt resistant varieties, less infestation of pest are recommended in Uttar Pradesh state. The findings are in line with that reported by Patil, *et al.*, 2018.

Cluster frontline demonstrations (CFLDs) organized by the MGKVK had enhanced the yield of pulse crops vertically and ensured rapid horizontal expansion of recommended technologies of the crops. The CFLDs made a positive and significant increase in yield of pigeon pea by 39.63 per cent and chickpea by 50.29 per cent. The CFLDs made a great impact on the use of improved varieties, weed management, fertilizer application plant protection measure, seed rate, seed treatment and sowing methodology and adoption of other recommended practices of pulse crops under study. In a nutshell, the overall trend in adoption of pigeon pea production technologies was increased by 211.46 per cent and chickpea crop production technologies by 285.76 per cent in selected villages. The old mix varieties of pulse crops were replaced by improved cultivars on a large scale in selected villages. The area under NA 2 variety of pigeon pea was raised from 8.00 to 45.00 ha and GNG variety of chickpea from 15.00 to 70.00 ha. This leads to conclude that CFLDs is proven extension intervention to demonstrate the production potential of pulse crops varieties on farmers' field.

Study recommends that extension agencies engaged in transfer and application of agricultural technologies on farmers' field should give priority to organize cluster frontline demonstrations (CFLDs) on large scale by adopting cluster approach for harnessing the productivity potential of pulse crops and to ensure rapid spread of flagship technologies developed by National Agricultural Research System (NARS). Furthermore, policy maker may provide adequate financial support to frontline extension system for organizing CFLDs under the close supervision of agricultural scientists and extension professionals. This varietal replacement strategy through CFLDs may help to increase the oilseed crops productivity at micro, meso and macro level.

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