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Enhancing the productivity and production of pulses through cluster Front line demonstrations and yield gap analysis in Tarai belt of eastern Uttar Pradesh

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Abstract
Cluster Frontline demonstration (CFLD) on pulse crops was carried out in 15 villages of 5 blocks in Gorakhpur district of Uttar Pradesh during kharif and rabi season of 2017-18, 2018-19 and 2019-20. Total 537 demonstrations on pigeon pea, chick pea, Field pea and lentil crops were carried out in area of 99.9 ha with the active participation of farmers. The objective of CFLD was to demonstrate the improved technologies of pulses for production potential. The improved technologies consisting use of improved variety, seed treatment with rhizobium and PSB culture, Sowing method, balanced fertilizer application and improved pest management techniques. The results of 3 years CFLD indicated that improved varieties with improved package of practice recorded higher yield as compared to farmer's practice. The improved technologies recorded higher mean seed yield of 18.62 q/ha, 23.66 q/ha, 16.23 q/ha and 16.09 q/ha in pigeon pea, chick pea field pea and lentil respectively, than 13.88, 16.36, 12.76 and 12.15 q/ha recorded under farmers practice. The average percentage increased in the yield over farmer's practices was 34.3 in pigeon pea, 44.6 in chickpea, 27.2 in field pea and 27.13 in lentil. The mean technological yield gap was recorded highest in pigeon pea (6.37 q/ha) followed by lentil (5.90 q/ha) and field pea (5.76 q/ha) while lowest in chickpea (1.33 q/ha). Maximum mean extension yield gap in study was recorded 7.3 q/ha in chickpea followed by pigeon pea (4.74 q/ha) and lentil (3.94 q/ha) while lowest extension yield gap was recorded in field pea (3.46 q/ha). The mean technology index varied from 5.33 to 27.78% while lowest (5.33) recorded with chickpea**.** Highest gross return (Rs. 10323/ha), net return (Rs. 80890/ha) and benefit cost ratio (4.06) was recorded with chickpea demonstration followed by pigeon pea and field pea while lowest gross return (Rs. 50593/ha), net return (Rs.27398 /ha) and benefit cost ratio (2.17) which was markedly higher compared to gross return (Rs. 39715/ha), net return (Rs.16587 /ha) and benefit cost ratio (1.71) in farmers practice. The improved technologies gave higher gross return, net return with higher benefit cost ratio compared to farmer's practices.

Keywords: pulses, yield, technology gap, extension gap technology index and economic returns, and CFLD

Introduction
Pulses, as an important source of protein, constitute a basic ingredient in the diet of vast majority of poor and vegetarian population in India. Supplemented with cereals, pulses provide a perfect mix of vegetarian protein of high biological value. The results from household consumption surveys indicate decline in the consumption of pulses leading to increase in malnutrition and decline in protein intake (Shailendra *et al*., 2013) [12]. India is still a home to about 24% of undernourished people in the world (Sharma *et al*., 2016) [13]. About 15.2% of people in India are undernourished. This signifies the importance of pulses in food and nutrition security for Indian population. The per capita net availability of pulses in the country was 70.3 g/day/capita in 1956, which has reduced to 37.5 g/day/capita in the year 1981 and further dropped to 29.1 g/day/capita in the year 2003. However, with the increase in production of pulses particularly in the recent decade mainly owing to yield increase supported with the policy and programmes to boost domestic production and increased imports, availability of pulses in the country has started improving and presently reached 47.2 g/day/capita (GoI, 2016) [6]. A study by the NCEAR (2014) [10] also reported that growth in pulses production (less than 1% annual growth) was less than half of the growth rate in Indian human population during the past 40 years, resulting in sharp decline in per capita production and availability of pulses in the country.

The Indian Institute of Pulses Research, Kanpur, has projected the country's demand of pulses at 39 million tonnes by 2050, which will require pulses production to grow at an annual rate of 2.2% (IIPR, 2015) [7]. To fulfill the growing requirement, the country has to produce enough pulses as well as remain competitive to protect the domestic production. To achieve this, it is imperative to develop and adopt more efficient crop-production technologies along with favorable policies and market support to encourage farmers to bring more area under pulses.

Total Pulses production during 2019-20 is estimated at 23.02 million tones which is higher by 2.76 million tonnes than the Five years' average production of 20.26 million tonnes (The Economics times 2020) [3]. India is the largest producer and consumer of pulses in the world accounting for about 29 per cent of the world area and 19 per cent of the world's production. Even more importantly India is also the largest importer and processor of pulses in the world. The average productivity of country is about 841 kg/ha against the average global productivity of 1023 kg/ha (DES, 2018) [1]. The average productivity of pulses in Uttar Pradesh was 973 kg/ha in 2017-18 (FAS-NR book, 2018). The area, production and productivity of pulses of Uttar Pradesh and in district Gorakhpur is also quite low as compared 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. To increase production and productivity of legumes, various types of efforts have been made by the farmers and agricultural researchers from time to time. Thus, there is a great challenge for policy makers, farm scientists extension functionaries farming community to enhance pulse productivity diversify their cropping systems to meet out the national local pulse requirements. The cluster frontline demonstration programme (CFLDs') in pulses is a unique programme started by Ministry of Agriculture, Govt. of India, conducted under close supervision of farm scientists. Main objective of CFLDs' in pulses is to demonstrate popularize the improved agro technology on farmers' fields under varied farming situations for effective transfer of generated technology fill the gap between improved technology adopted/indigenous technology to enhance pulse productivity farm gains for sustaining the production systems especially under rainfed farming (Choudhary *et al*., 2009b) [2]. Keeping in view the above facts, an intensive intervention such as cluster front-line demonstrations was conducted to transfer the generated farm technology through FLDs' in pulses under tarai belt of eastern Uttar Pradesh with the objectives of enhancing productivity, profitability narrowing in the extension yield gaps. Technological extension yield gaps under pulses in this comprehensive study are also presented in this paper for framing appropriate extension strategy for effective transfer of technology to target farmers in the district Gorakhpur introduce and disseminate improved varieties of Kharif pulse (*Pigeon pea*) and rabi pulses (Chick pea, Field pea and lentil) to increase the crop yield during 2017-18, 2018-19 and 2019-20.

Indian Council of Agricultural Research (ICAR) had established Krishi Vigyan Kendras (KVKs) Farm Science Centers' all over the India, is an institutional innovation for application of agricultural technologies at the farmer's field with the help of a multi-disciplinary team. The important activity of KVKs is to conduct frontline demonstrations (FLDs) on flag ship technologies developed by NARS on farmer's field. Therefore, KVKs system emphasizes the frontline demonstration as a long-term educational activity in a systematic manner on farmers' field under the close supervision of agricultural scientists to show the worth of new practice/technology. Keeping in view the demand of pulse for the increasing population KVK Belipar Gorakhpur under the guidance of the Acharya Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya and ATARI Kanpur initiated to organize the cluster frontline demonstration at farmers field with the objective to demonstrate the improved pulse production technology in Gorakhpur district and boost the pulse production.

Materials and Methods

Krishi Vigyan Kendra Belipar, Gorakhpur conducted cluster frontline demonstration on improved production technologies for pulse crops *viz*. Pigeon pea (*Cajanus cajan* L.), Field pea (*Pisum sativum*), Chick pea (*Cicer arietinum* L.) and Lentil (*Lens culinaris* L.) during 2017-`8, 2018-19 and 2019-20 in 15 villages of 5 block *viz* Kodiram, Gagha, Badahalganj, Gola Piprauli and Belghat in 99.9 ha area of district Gorakhpur covering 537 farmers (Table-1). Recommended package of practice were adopted in demo plots while in control plot crop was grown as per the farmer practice generally adopted by individual farmer. District Gorakhpur of Uttar Pradesh state falls under north eastern plain zone having sandy loam to loam soil with a organic carbon 0.2-0.3 percent. Soils of the CFLD plots were low in N and medium in P and K availability. The primary data on grain yield farmers' practices was collected from the beneficiary farmers through crop cutting methodology followed by personal interviews. The yield increase in demonstrations over farmers' practice was calculated by using the following formula:

Table 1: Technology demonstrated in CFLD at Gorakhpur

Crop	Technology Component	Demonstration Plot	Farmers Practice
Pigeon pea	Variety	Narendra Arhar-1 (Wilt and sterility mosaic resistant)	Bahar
	Seed rate	15 kg/ha	12 kg/ha
	Seed treatment	seed treatment with carbendazim @ 2g/kg seed + Rhizobium culture + PSB @ 200g/10 kg seed	No seed treatment
	Sowing method	Raised bed sowing	Broadcasting
	Fertilizer	100 kg DAP/ha	Urea 50 Kg/ha
	Weed management	Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + Imazethapyr 10% SL @ 1000 ml/ha	Manual Weeding at 35 to 45 days after sowing
	Plant protection	Indoxacarb 15.8% E.C. @ 500 ml/ha at 50% flowering and pod filling stage	Imidachloprid @ 250 ml/ha after incidence of insect

	Technical guidance	Time to time	Attend Kisan gosthi
Chickpea	Variety	GNG-1851	Avrodhi
	Seed rate	40 kg/ha	40 kg/ha
	Seed treatment	seed treatment with carbendazim @ 2.5g/kg seed + PSB @ 5g/ kg seed	No seed treatment
	Sowing method	Line sowing	Broadcasting
	Fertilizer	100 kg DAP/ha	Urea 50 DAP/ha
	Weed management	Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + Hand weeding at 45 days	Manual Weeding at 35 to 45 days after sowing
	Plant protection	Indoxacarb 15.8% E.C. @ 500 ml/ha at 50% flowering and pod filling stage	Imidachloprid @ 250 ml/ha after incidence of insect
	Technical guidance	Time to time	Attend Kisan gosthi
Field pea	Variety	Aman	Local
	Seed rate	80 kg/ha	100 kg/ha
	Seed treatment	seed treatment with carbendazim @ 2g/kg seed + PSB @ 5g/ kg seed	No seed treatment
	Sowing method	Line sowing	Broadcasting
	Fertilizer	100 kg DAP/ha	DAP 50 Kg/ha
	Weed management	Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + Hand weeding at 45 days	Manual Weeding at 35 to 45 days after sowing
	Plant protection	Indoxacarb 15.8% E.C. @ 500 ml/ha pod filling stage	Imidachloprid @ 250 ml/ha after incidence of insect
	Technical guidance	Time to time	Attend Kisan gosthi
Lentil	Variety	PL08/IPL 316	PL 406/ NL-1/PL08
	Seed rate	45 kg/ha	50 kg/ha
	Seed treatment	seed treatment with carbendazim @ 2g/kg seed + PSB @ 5g/ kg seed	No seed treatment
	Sowing method	Line sowing	Broadcasting
	Fertilizer	100 kg DAP/ha	DAP 50 Kg/ha
	Weed management	Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + Hand weeding at 45 days	Manual Weeding at 35 to 45 days after sowing
	Plant protection	Ememectin benzoate 5% SG @ 300g /ha pod filling stage	No use
	Technical guidance	Time to time	Attended Kisan gosthi

% Yield increase over farmers' practice=Demonstration average plot yield—farmers average

plot yield /Farmers average plot yield X 100

Estimation of technology gap, extension gap technology index: The estimation of technology gap, extension gap technology index was done using following formula (Kadian *et al.* 1997; Samui *et al.* 2000) [9, 11]:

1. Technology gap = Potential yield-Demonstration plot average yield
2. Extension gap= Demonstration plot average yield - Farmer's plot average yield
3. Technology Index= (Pi–Di)/Pi x 100

Where,
Pi = Potential yield of i^{th} crop
Di =Average demonstration plot yield of i^{th} crop.
Economic analysis of front line demonstration's (CFLDs) on pulses was done using existing price of inputs while gross return was calculated as per sale price of the produce.

Results and Discussion

Seed yield

The average yield of pulses [*Pigeon pea* (18.62 q/ha), chickpea (23.66 q/ha), field pea (16.23 q /ha) and lentil (16.09 q/ha)] were much higher as compared to average yield of farmers practices [*Pigeon pea* (13.88 q/ha), chickpea (16.36q/ha), field pea (12.76 q /ha) and lentil (12.15 q/ha)]. The average percentage increased in the yield over farmer's practices was 34.3 in pigeon pea, 44.6 in chickpea, 27.2 in field pea and 27.13 in lentil. The results indicated that the cluster front line demonstrations have given a good impact over the farming community of Gorakhpur district as they were motivated by the new agricultural technologies applied in the CFLD plots (Table 2). This finding is in corroboration with the findings of Singh *et al*., (2020) [14].

Technological gap

Highest technological gap was recorded in pigeon pea (7.8 q/ha) during 2019-20 while lowest in chickpea (0.3 q/ha) during 2018-19. The mean technological yield gap was recorded highest in pigeon pea (6.37 q/ha) followed by lentil (5.90 q/ha) and field pea (5.76 q/ha) while lowest in chickpea (1.33 q/ha) (Table 2). This might be attributed mainly due to lack of irrigation infrastructure, ill distribution of rainfall, variation in soil fertility, cultivation on marginal soils, non congenial weather conditions local specific crop management problems faced in order to harness the yield potential of specific crop varieties under demonstration plots (Choudhary *et al.* 2009b) [2]. These observations indicate that location specific crop management is needed of the hour to bridge the gap in potential demonstration yields (Vedna *et al*., 2007) [15].

Extension yield gap

Maximum extension yield gap of 8.4 q/ha was observed in chickpea var. GNG 1581 during 2018-19 while lowest in lentil during 2018-19. Mean maximum extension yield gap in study was recorded 7.3 q/ha in chickpea followed by pigeon pea (4.74 q/ha) and lentil (3.94 q/ha) while lowest extension yield gap was recorded in field pea. Higher extension gap in chickpea and other pulse crop include in the study indicates that there is a strong need to aware and motivate the farmers for adoption of improved farm 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. The new technologies will eventually lead to the farmers to discontinue the existing local practices and to adopt new technologies (Table 2) in pulses. Refinement in the local farmers' practices for higher adoption of location specific generated farm technology for sustaining crop productivity is another option open for the research scientists (Kumar *et al.* 2019) [4]. This study clearly speaks that extension functionaries of district Gorakhpur have to strictly focus on dissemination of proven farm technologies in pulse production systems to enhance the pulse productivity over existing levels.

Table 2: Effect of technologies used on pulses yield, different gaps in yield and technology index

Year	Crop/ variety	No of FLD	Area (ha)	Potential Yield (q/ha)	Yield (q/ha)		% increase in yield	Technology gap(q/ha)	Extension Gap(q/ha)	Technology index (%)
					Demo	FP (Check)				
2017-18	Pigeon pea/ NA-1	56	10	25	20.37	14.75	37.96	4.63	5.62	18.5
2018-19		43	10	25	18.3	14.6	25.34	6.70	3.7	26.8
2019-20		51	10	25	17.2	12.3	39.8	7.8	4.9	31.2
Total/ mean		150	30		18.62	13.88	34.36	6.37	4.74	25.5
2017-18	Chickpea	45	10	25	22.5	16.6	35.54	2.5	5.9	10.0
2018-19		50	10	25	24.7	16.3	51.53	0.3	8.4	1.2
2019-20		32	5	25	23.8	16.2	4691	1.20	7.6	4.8
Total/ mean		127	35		23.66	16.36	44.66	1.33	7.3	5.33
2017-18	Field pea/ Aman	59	4	22	15.6	12.10	28.92	6.40	3.50	29.09
2018-19		40	5.4	22	16.4	12.80	28.12	5.60	3.60	24.45
2019-20		59	4	22	16.7	13.4	24.62	5.3	3.3	24.09
Total/ mean		158	13.4		16.23	12.76	27.22	5.76	3.46	25.87
2017-18	Lentil/ PL 08	36	10	22	14.8	11.7	26.49	7.2	3.10	32.72
2018-19	PL 08	26	10	22	14.5	11.9	21.84	7.5	2.6	34.09
2019-20	IPL 316	40	7.5	22	16.58	12.46	33.06	5.42	4.12	24.63
Total/ mean		102	27.5		16.09	12.15	27.13	5.90	3.94	27.78

Demo= Demonstration, FP= Farmers practice

Technology Index

The technology index shows the feasibility of the evolved technology at the farmer's fields and the lower the value of technology index more is the feasibility of the technology (Jeengar, *et al*., 2006) [8]. Lowest technology index was recorded in chickpea (5.33%) which indicates that technology dissemination through CFLD was very much feasible for the district Gorakhpur and adopted magnificently by the farmers. Overall mean technology index varied from 5.33 to 27.78% which shows the effectiveness of the technology demonstrated through CFLD. It may be attributed to the selection of varieties suitable for the area coupled with proven location specific pulse production technology and intensive awareness campaign by the scientist of KVK Gorakhpur.

Economic returns

The economics of improved production practice under front line demonstrations were estimated on the basis of prevailing market rates. Highest gross return (Rs. 10323/ha), net return (Rs. 80890/ha) and benefit cost ratio (4.06) was recorded with chickpea demonstration followed by pigeon pea and field pea while lowest gross return (Rs. 50593/ha), net return (Rs.27398 /ha) and benefit cost ratio (2.17) was recorded with lentil which was markedly higher than the returns obtained in plots of farmers practice (Table 3). Higher monetary returns as well as B:C ratio through improved pulse production technologies have also been reported by Kumar *et al.* (2019) [4] and Singh *et al.* (2020) [14].

Table 3: Effect of technologies used on economics of CFLD on pulses at Gorakhpur

Year	Crop/ variety	Cost of cultivation (Rs/ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B:C ratio		Sale price (q/ha)
		Demo	FP	Demo	FP	Demo	FP	Demo	FP	
2017-18	Pigeon pea/ NA-1	28700	26500	79120	50400	50420	30080	2.75	2.13	4600
2018-19		28700	26500	91500	56580	62800	46500	3.18	2.75	5000
2019-20		23900	22500	91665	73000	43875	43875	1.95	1.95	4500
Mean		27100	25166	87428	66318	52365	40151	2.62	2.27	
2017-18	Chickpea	27500	26800	107100	72900	79600	46100	3.89	2.72	4500
2018-19		25900	25900	11362	74980	87720	49080	4.39	2.89	3000
2019-20		25900	25900	101250	74700	75350	48800	3.90	2.88	4500
Mean		26433	26200	107323	74193	80890	47993	4.06	2.83	
2017-18	Field pea/ Aman	22400	22400	58450	46900	36050	24500	2.47	2.09	3500
2018-19		22200	22200	49200	38400	27000	16200	2.21	1.72	3000
2019-20		21500	21500	46800	36300	25300	14800	2.17	1.68	3000
Mean		22033	22033	51483	40533	29450	29450	2.33	1.83	
2017-18	Lentil/ PL 08	26468	24484	58021	43627	3336	19143	2.35	1.78	3500
2018-19	PL 08	22800	22800	46400	38080	23600	15280	2.03	1.67	3200
2019-20	IPL 316	22100	22100	47360	37440	25260	15340	2.14	1.69	3200
Mean		23195	23148	50593	39715	27398	16587	2.17	1.71	

Conclusion

On the basis of 3 years results of CFLD it was concluded that technologies disseminated for chickpea demonstration was up to the mark though there is scope to focus on improvement of pigeon pea, field pea and lentil yield using recent technologies for enhancing the pulse productivity.

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