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Integrated insect-pest and disease management for productivity enhancement in pulse crops

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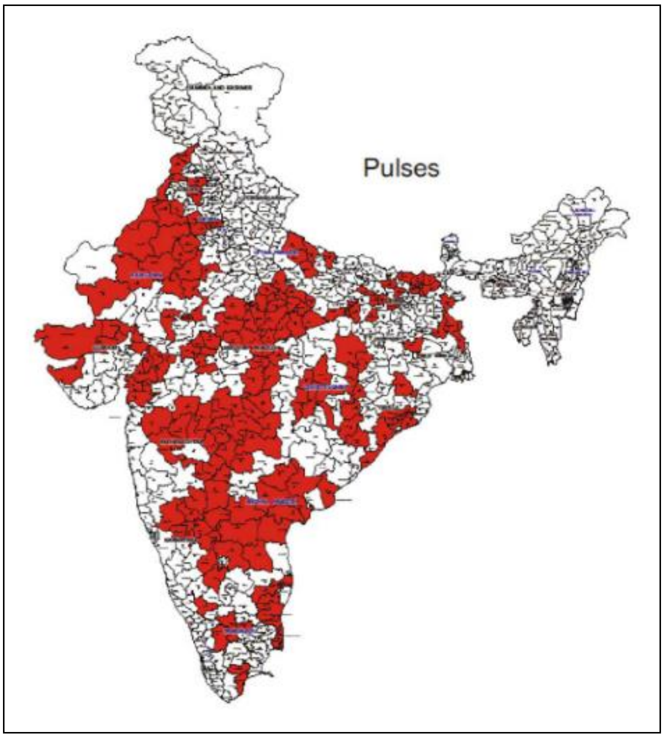
Abstract
Mahayogi Gorakhnath Krishi Vigyan Kendra, Gorakhpur, Uttar Pradesh, conducted 175 and 35 demonstrations on pigeon pea and chickpea for productivity enhancementduring 2017-18 and 2018-19 respectively. The findings in respect of pigeon pea and chickpea, overall yield trend of demonstrations ranged 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 existing practices because of considerable variation in the extent of adoption of improved technology with IPM strategies depending upon the amount of risk involved in terms of cost, convenience, skill and knowledge about the concerned practice. The average per cent reduction in affected plant/m^2 and per cent reduction in affected pod/plant were recorded 47.88 and 40.63 in pigeon pea and 48.22 and 43.85 in chickpea, respectively. The overall disease reduction was recorded 44.55 per cent in pulse crops.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 performance of improved technology with IPM practices was found significantly most effective in controlling least number of affected plants/m^2 as well as least number of pods/plants and least disease incidence. The productivity was better over existing practices under demonstrations. Hence, pulses production and protection technology have a broad scope for increasing the area and production of pulses at each and every level i.e., Farmers, State and National level.

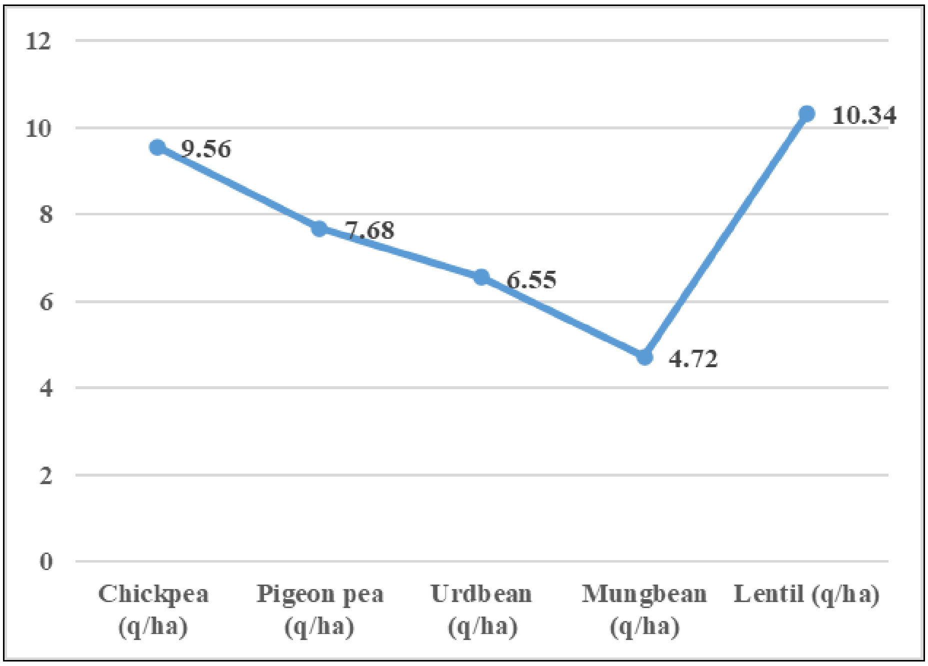
Keywords: IPM strategies in pulse crops, pod borer, wilt and collar rot, yield and economics

Introduction
Pulses constitute a very important dietary constituent for human and animal because of their richness with proteins (ranging from 20 to 24 per cent, depending upon the crop species) and essential minerals, vitamins and dietary fibres. The protein content of grain legumes is double that of wheat and three times that of rice. Therefore, pulses as a complement to cereals, make one of the best solutions to protein-calorie malnutrition. Moreover, its soil rejuvenation qualities such as release of soil-bound phosphorous, fixation of atmospheric nitrogen, recycling of soil nutrients and addition of organic matter and other nutrients make pulses an ideal crop of sustainable agriculture. India is the largest producer in the world, with 26 per cent share in the global production by producing 25.23 million tons of pulses from an area of 29.99 million hectares. The average productivity of country is about 841 kg/ha against the average global productivity of 1023 kg/ha Directorate of Economics and Statistics, (2018) [4]. In Uttar Pradesh, the total production and productivity of pulses during 2018-19 were 2.40 million tonnes and 1044 kg/ha respectively, Pocket Book of Agricultural Statistics, (2019) [12]. The important production share of pulse crops is Chickpea (45.53 per cent), Pigeon pea (17.06 per cent), Urdbean (13.40 per cent), Mung bean (7.76 per cent), Lentil (5 per cent) and Field pea (5 per cent). The major pulse producing states are 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, Directorate of Economics and Statistics, (2018) [4].

In general, declining of potential yield of pulse crops have significant instability, mainly due to its cultivation on marginal lands under poor management, adoption of inappropriate production technology (old/mixed and susceptible varieties, higher seed rate, improper method of sowing and weed management, poor plant protection measure) and heavy infestation of biotic stresses i.e. wilt (*Fusurium oxysporum* f. sp. *ciceri*), collar rot (*Selerotium rolfsii* Sacc.) and pod borer (*Helicoverpa armigera* (Hubner) at different crop growth stages of pigeon pea and chickpea. The dominated soil borne diseases i.e. wilt and collar rot causes 10% seedling mortality in pigeon pea and chickpea reported by Sharma *et al.*,(2015) [15]and incidence of pod borer, if not controlled, can cause 70% yield losses alone discourage farmers to grow pulse crops, Sharma *et al.*,(2016) [16] and Kumar, *et al.*,(2019) [8]. Lal *et al*., (1992) [9] reported per cent infestation of seed by pod fly (*Melanagromyza obtusa*) ranges 14.3-46.6% and pod bug (*Clavigralla gibbosa*) damage to pods and grains of pigeon pea showed a loss to the tune of 25.2 and 20.3 per cent, respectively, Veda, (1993) [21].Chemical controls are the only strategy being currently adopted by the farmers and rely on synthetic organic insecticides to manage the insect-pests in pulse crops. This increases the risk of environmental contamination, loss of biodiversity and development of insecticide resistance in pod borer, pod fly and other pests. Integrated pest management (IPM) strategies, uses a combination of management practices among which cultural, mechanical, biological and chemical means of pest control are important but the farmers are not aware to these management technologies. To overcome the present crisis, the farmer to be paid more attention to integrated approach for pest management. Keeping this in view, IPM strategies through cluster front line demonstrations were conducted for harnessing the productivity potential of pigeon pea and chickpea crop, reduce the technology gap and minimizing the insect and disease infestation.



Major pulses producing states of India (Indicates in red colour)



Pulses productivity of India (DES, 2018)

Materials and Methods

Mahayogi Gorakhnath Krishi Vigyan Kendra, Gorakhpur had conducted the cluster front line demonstrations on pulse crops during *kharif* and *rabi* season 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. A list of farmers was prepared from group meeting and specific skill training was imparted to the selected farmers. The production technologies with IPM strategies on pulse crops were comprised of suitable improved varieties of pigeon pea and chick pea that was NA 2 and GNG 1581 respectively and demonstrated with full package of practices viz. 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. In this demonstration control plot was also kept where farmers (existing) practices were carried out(use of non-descriptive varieties, broadcasting sowing method, no use of fertilizer, one hand weeding and indiscriminate use of plant protection measures). The demonstrations on farmers' fields were monitored by scientists of Mahayogi Gorakhnath Krishi Vigyan Kendra, Gorakhpur right from sowing to harvesting and made to guide them. The yield data were collected from the demonstrations and control plots and analyzed with the suitable statistical tools for different parameters using following formula as given below: -

Per cent increase in yield (%) = Yield gain in IT plot (q/ha) - Yield gain in EP plot (q/ha)/Yield gain in EP plot (q/ha) x 100

Insect-pest and disease incidence (%) = Number of infected plant unit/Total no. of plant unit (healthy +infected) x100

Partial budgeting technique, Birthal, (2003) [1] was used to estimate additional net return, cost benefit ratio (B:C ratio) and incremental cost benefit ratio (ICBR) of the demonstration. The technology is economically feasible if the profits are higher compared to those farmers' practice. This could be symbolically represented as follows:

TR (IT) – TR (FP) > TC (IT) –TC (FP)

DR (IT) > DC (FP); TR = Σ Pi. Yi

TC = Σ Pj. Xj

Where, TR (IT) = Total return from the improved technological intervention (IT), TR (F) = Total returns from farmers' practice plot; TC (F) = Total cost recorded in farmers' practice plot; DR (IT) = Change in the revenue due to improved technology; DC (FP) = Change in the revenue due to farmers' practice; TR (IT) = Total return from the improved technology plot; TC (IT) = Total cost from the improved technology plot; Pi = Price of the i^{th} output (i= 1,….,n) ; Yi = quantity of the i^{th} output (i= 1,….,n) ; Pj = Price of the j^{th} input (j= 1,….,n) and Xj = quantity of the j^{th} input (j= 1,….,n).

The yield gap was also comprising at least two components i.e. Yield gap I and Yield gap II. 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 4) were estimated as follows:

Yield Gap I= $[(Y_P - Y_D)/Y_P]$ x 100

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

Yield parameters of both demonstrations and check involving farmers practices were recorded and calculated as suggested by Dayanand *et al.* (2012) [3].

Additional cost in improved technology (ACIT in Rs/ha) = Cost of improved technology (Cit) - Cost of farmers practice (Cfp)

Additional returns (Ar in Rs/ha) = Net returns of improved technology (Nrit) - Net returns of farmers practice (Nrfp)

Effective gain (Eg in Rs/ha) =Additional returns of improved technology (Arit) -Additional cost of improved technology (Acit)

Benefit cost ratio (BCR) = Gross monetary returns in Rs/ha (GMR) /Gross monetary expenditure in Rs/ha (GME)

Incremental cost benefit ratio (ICBR) = Additional net returns in Rs/ha (Anr)/ Additional cost of improved technology (Acit) in Rs/ha

Results and Discussion

Technological adoption gaps between improved technology and existing practices:

Full gap was identified for use of high yielding varieties, seed rate, seed treatment and sowing methods. Fertiliser management, weed management, irrigation and plant protection measure showed partial adoption gap, which definitely was the reason of not achieving potential yield. Land preparation and time of sowing showed no adoption gap as presented in Table 1.

Farmers in general used local or old-age varieties instead of the recommended high yielding resistant varieties. Unavailability of seed in time and lack of awareness were the main reasons. Farmers applied higher seed rate than the recommended and they were not using seed treatment technique for wilt and collar rot management and to better nodulation for biological nitrogen fixation (BNF) of the plants because of lack of knowledge and interest. The farmers were much concerned about importance of sowing method and land preparation. Burman *et al.*, (2010) [2] reported that there is a gap in adoption of technology in major pulse crops both in rain fed and irrigated cropping system.

Impact of improved technology with IPM strategies on insect-pest/disease reduction and yield of pulse crop:

The performance of improved technology was found most effective in controlling least number of affected plants/m^2 as well as least number of pods/plants (Table 2). The average per cent reduction in affected plant/m^2 and per cent reduction in affected pod/plant were recorded 47.88 and 40.63 in pigeon pea and 48.22 and 43.85 in chickpea, respectively. The average disease reductions (collar rot/wilt) were recorded 44.40 and 44.70 per cent in pigeon pea and chickpea respectively. 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 50.29per 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) [6] and Singh *et al.*, (2020) [18].

Impact of improved technology with IPM strategies on productivity enhancement in pulse crops:

The technological interventions comprising high yielding varieties seeds, recommended seed rate, seed treatment, time and method of sowing, recommended dose of fertilizers, weed management and proper plant protection measures were used as per package and practices in pulse crops. Impact of technological interventions in terms of productivity enhancement in pulse crops as shown in Table 3. The yield parameter also compared at district, state and national level productivity, it reflected significantly more over district, state and national level productivity in all the crops. The result clearly indicated that the average pigeon pea productivity was recorded as 14.34q/ha from demonstrated plot. The highest average pigeon pea productivity i.e. 14.64 q/ha received during 2017-18 followed by 14.04 q/ha in 2018-19. 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). Singh *et al.*, (2015) [17] also reported similar findings in chickpea crop under crop cafeteria during 2014-15 crop seasons. Similar findings have also been reported by Singh *et al.*, (2020) [18] in chickpea crop.

The results of demonstrated technologies of chickpea elicited in table 3 that chickpea yielded average productivity i.e. 17.56 q/ha from demonstrated plot. The maximum average productivity was 18.16q/ha in 2018-19 followed by 16.95q/ha in 2017-18. 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) [17] also reported similar findings in chickpea crop under crop cafeteria during 2014-15 crop seasons. Similar findings have also been reported by Singh *et al.*, (2020) [18] in chickpea crop.

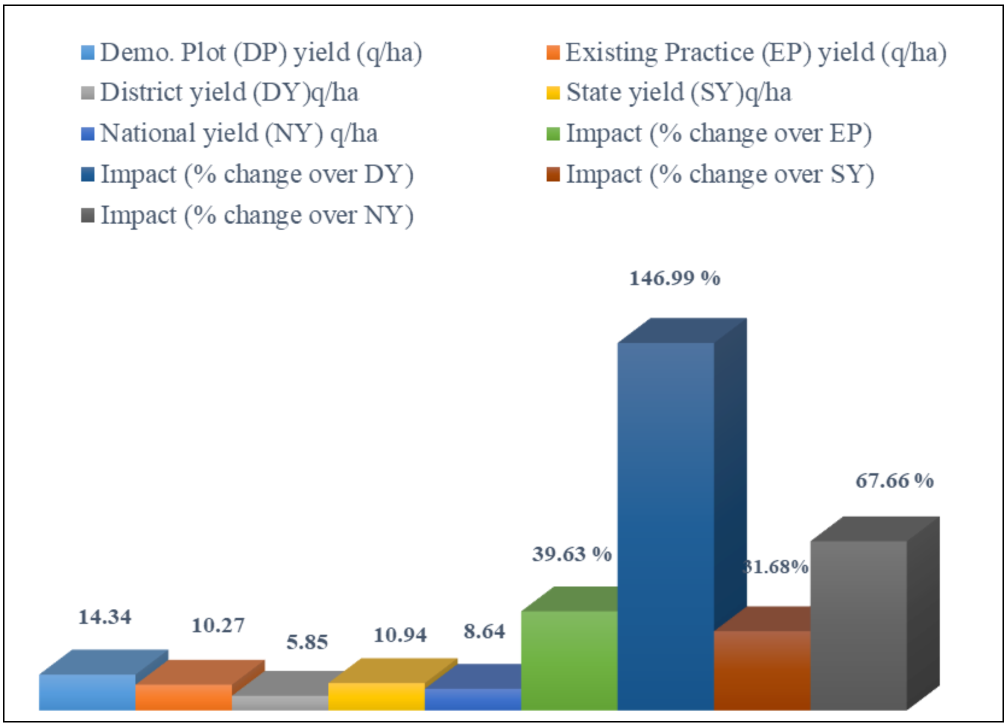


Fig 1: Impact of improved technology with IPM strategies on productivity of pigeon pea

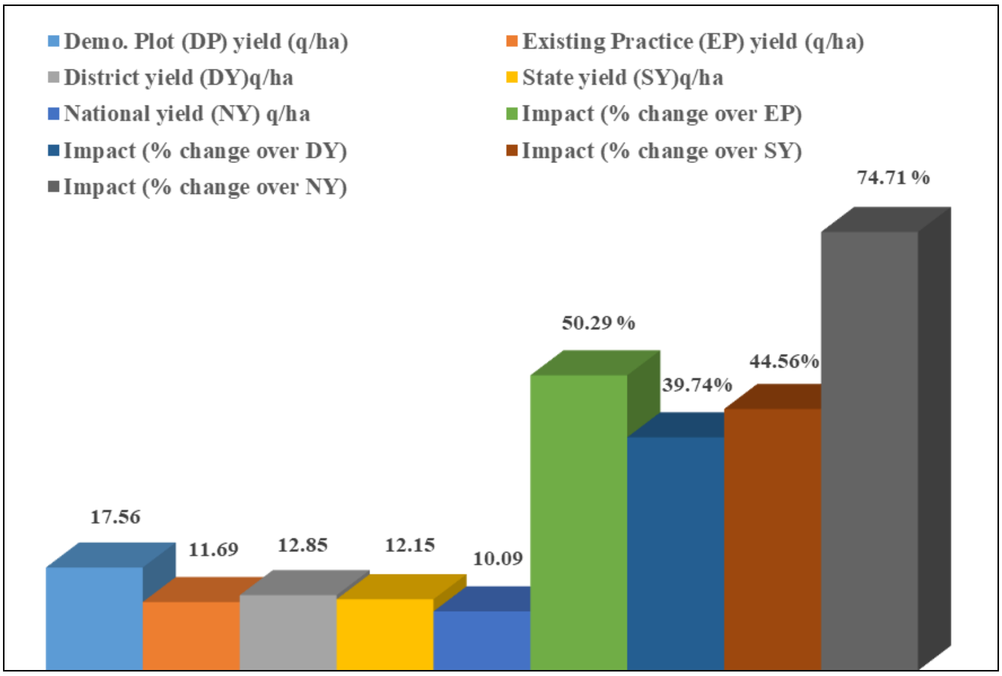


Fig 2: Impact of improved technology with IPM strategies on productivity of chickpea crop

Impact of improved technology with IPM strategies on 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 4). 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) [11] and Sultana *et al.*, (2019) [20]. Yield gap of different crops (Fig. 3) was also analyzed with average yield of district, state and national are depicted in table 5 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) [19] and Raj *et al.*, (2013) [14]. 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 productivity of pulse crops by adopting improved technologies with IPM strategies.

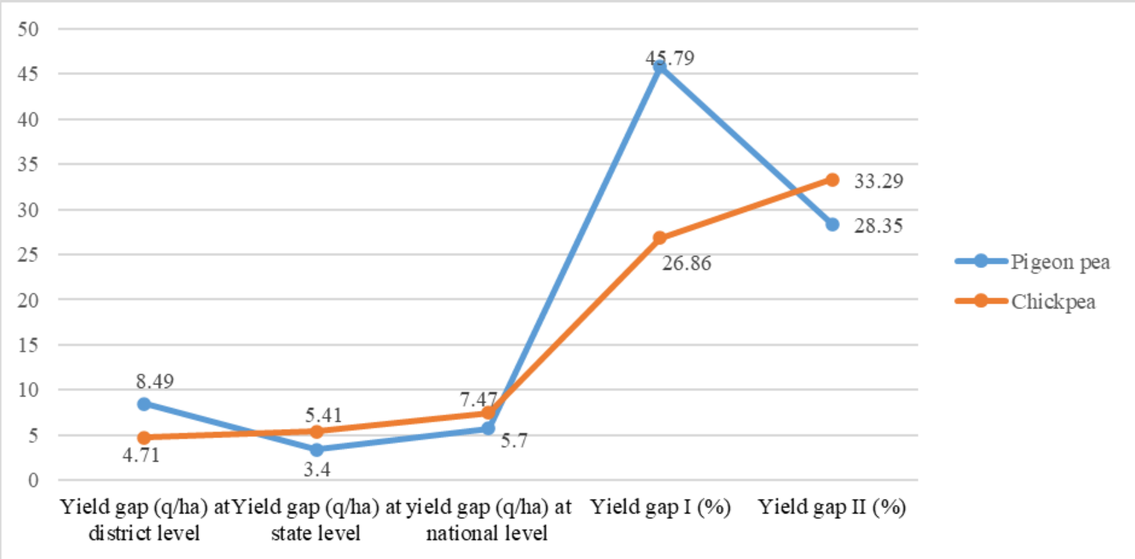


Fig 3: Impact of improved technology with IPM strategies on pulse crops in relation to yield gap (q/ha)

Impact of Improved technology with IPM strategies 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 5. 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 2.42from farmers practice.The average incremental cost benefit ratio was 10.88 and10.25 in pigeon pea and chickpea respectively, indicating a good return of each additional rupee invested on IT in all the pulse crops separately.Similar findings were also reported by Lathwal, (2010) [10], Dwivedi *et al.*, (2014) [5] and Rachhoya *et al.*, (2018) [13] in frontline demonstrations on pulse crops.

Table 1: Differences between improved technology with IPM strategies and existing practices under frontline demonstrations in pulse crops

SN	Particulars	Improved technology with IPM strategies		Existing Practices	Technological Gap
		Pigeon pea	Chickpea		
1.	Land preparation	One cultivator ploughing and 3 ploughing	One cultivator ploughing and 2 ploughing	One cultivator ploughing and 3 ploughing	No gap
2.	Variety	NA 2 (potential yield 25 q/ha)	GNG1581 (potential yield 24 q/ha)	Old mix and unidentified	Full gap (100%)
3.	Time of sowing	First fortnight of June to first fortnight of July	Second fortnight of October to first fortnight of November	As per recommendation	No gap
4.	Seed rate (Kg/ha)	15	80	Higher seed rate	Full gap (100%)
5.	Sowing method	Line sowing Raised bed 60 x 15cm (R x P)	30x10cm (R x P)	Broadcasting	Full gap (100%)
6.	Seed treatment	Carbendazim @ 2g/kg seed +*Rhizobium* culture @ 5 g/kg seed during 2017-18 and 2018-19	Carbendazim @ 2g/kg seed + PSB culture @ 5gm/kg seed (2017-18) and in 2018-19 seed treatment with Trichoderma @ 5 g/kg seed	No seed treatment	Full gap (100%)
7.	Fertilizer dose (Kg/ha)	18 N and 46 P_2O^5	18 N and 46 P_2O^5	Use of Imbalance fertilizers	Partial gap (15-25% more than recommendation)
8.	Weed management	Pendimethalin 30% EC @ 3.3 lit./ha as pre- emergence + One hand weeding at 45-60 days after sowing	Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + One hand weeding at 60 days after sowing	Improper chemical weed management	Partial gap
9.	Irrigation	In absence of rain, at flowering /pod development stage	One at pre flowering and one at pod development stage	Untimely irrigation	Partial gap
10.	Plant protection (Pest management)	Indoxacarb 15.8% E.C. @ 500 ml/ha at 50% flowering and pod filling stage (2017-18)/ in 2018-19 Emamectin benzoate 5% SG @220g/ha at 50% flowering and pod filling stage	Neem oil 0.15% @ 2 ml/lit. of water at 50% flowering + Emamectin benzoate 5% SG @220g/ha at 50% pod filling stage during 2017-18 and 2018-19	Indiscriminate use of plant protection measures	Partial gap

Table 2: Impact of improved technology with IPM strategies on insect-pest/disease reduction and yield of pulse crop

Name of crop	Year	Under C-FLD programme		Average yield (qt/ha)		Impact (% change)	Average % reduction (pod borer) in affected plant/m^2	Average % reduction (pod borer) in affected pod/plant	Average % reduction (collar rot/wilt incidence)
		No. of Demo.	Area (ha)	*DP	EP				
Pigeon pea (Kharif)	2017-18	50	20.00	14.64 (12.44-16.23)	10.27	+42.55	50.50	42.75	46.50
	2018-19	125	50.00	14.04 (13.10-18.40)	10.27	+36.70	45.25	38.50	42.30
Total/Average		175	70.00	14.34 (12.77-17.32)	10.27	+39.63	47.88	40.63	44.40
Chickpea (Rabi)	2017-18	10	2.15	16.95 (15.65-18.30)	11.88	+42.67	52.00	42.86	48.80
	2018-19	25	10.00	18.16 (16.80-20.60)	11.50	+57.91	44.44	44.83	40.60
Total/Average		35	12.15	17.56 (16.23-19.45)	11.69	+50.29	48.22	43.85	44.70
Overall Total/Average		210	72.15	15.95	10.98	+44.96	48.05	42.24	44.55

Demo.= Demonstration; DP= Demonstrated Plot; EP= Existing practice;
*Figures in parentheses indicate lowest and highest yield of demonstrated farmer

Table 3: Impact of improved technology with IPM strategies in terms of productivity enhancement in pulse crops

Crop name	Year	Average yield (q/ha)		District yield (DY) q/ha	State yield (SY) q/ha	National yield (NY) q/ha	Impact (% change over EP)	Impact (% change over DY)	Impact (% change over SY)	Impact (% change over NY)
		Demo. Plot (DP)	Existing Practice (EP)							
Pigeon pea	2017-18	14.64	10.27	5.40	11.80	9.60	+42.55	+171.11	+24.07	+52.50
	2018-19	14.04	10.27	6.30	10.08	7.68	+36.70	+122.86	+39.29	+82.81
Average		14.34	10.27	5.85	10.94	8.64	+39.63	+146.99	+31.68	+67.66
Chickpea	2017-18	16.95	11.88	10.70	11.60	10.63	+42.67	+58.41	+46.12	+59.45
	2018-19	18.16	11.50	15.00	12.70	9.56	+57.91	+21.07	+42.99	+89.96
Average		17.56	11.69	12.85	12.15	10.09	+50.29	+39.74	+44.56	+74.71

Source of district, state and national yield data: Directorate of Economics and Statistics, 2018[4] and FAOSTAT, 2019[21]

Table 4: Impact of IPM strategies 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)	

Source of district, state and national yield data: Directorate of Economics and Statistics, 2018[4] and FAOSTAT, 2019[21]

Table 5: Impact of improved technology with IPM strategies on Economics of pulse crops under real farm situation

Crops	Year	CoC (Rs/ha)		CoC increase over FP (%)	GMR (Rs/ha)		GMR increase over FP (%)	NR (Rs/ha)		NR increases over FP (%)	ACoC in IT(Rs/ha)	ANR (Rs/ha)	BCR		ICBR	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	13.20	18540
	2018-19	21255	19050	11.58	70200	51350	36.71	48945	32300	51.53	2205	16645	3.30	2.78	8.55	14240
Average		20723.50	18793.50	10.26	71700	51350	39.63	50976.50	32556.50	56.54	1930	18420	3.47	2.78	10.88	16390
Chickpea	2017-18	21171	17253	22.71	74580	47520	56.94	53409	30267	76.46	3918	23142	3.52	2.75	6.91	19224
	2018-19	24060	22100	8.87	72640	46000	57.91	48580	23900	103.26	1960	24680	3.02	2.08	13.59	22720
Average		22615.50	19676.50	15.79	73610	46760	57.43	50994.50	27083.50	89.86	2939	23911	3.27	2.42	10.25	20972

CoC= Cost of cultivation; IT= improved technology; FP= Farmers' practice GMR= Gross monetary returns; ACoC= Additional cost of cultivation

NR= Net Returns; ANR= Additional net returns; BCR= Benefit cost ratio; ICBR=Incremental cost benefit ratio

Conclusion

There was a technological difference between improved production technology with IPM strategies and farmer practices in pulse crops. The yield levels were considerably lower under existing practices because of considerable variation in the extent of adoption of improved technology with IPM strategies depending upon the amount of risk involved in terms of cost, convenience, skill and knowledge about the concerned practice.The demonstrations of improved production technology with IPM strategies of pulse crops made a positive and significant increase in yield of pigeon pea by 39.63 per cent and chickpea by 50.29 per cent. The performance of improved technology with IPM strategies was found most effective in controlling least number of affected plants/m^2 as well as least number of pods/plants and disease incidence also. The yield gap showed that the farmers were not aware about improved technologies, therefore, 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. The economic details of the demonstrations give us a green signal to further popularize them among the farming community for large scale adoption. Therefore, under this situation, extension agencies can also play a significant role to transfer improved technologies of pulse crops with IPM practices among farming communities for productivity enhancement. Thus, it can be said, that the adoption of improved package of practices of pulse production technology with IPM strategies may result in higher productivity per unit area.

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