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# Integrated pest management approach in pulse crops for sustainability of farmers income

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ABSTRACT

In the present experiment a total of 213 and 60 demonstrations were conducted on pigeon pea and chickpea crops respectively during three consecutive years from 2017–18, 2018–19, 2019–20 for productivity enhancement and sustainability of farmers income. The findings in respect to pigeon pea and chickpea, overall yield trend of demonstrations ranged from 12.43–17.38 q/ha and 14.62–18.97 q/ha and yield increase ranged from 36.70–43.14% and 42.67–57.91% over the local practices yield, respectively. The average percent reduction in affected plant/m$^2$ and percent reduction in affected pod/plant were recorded 45.92 and 40.42 in pigeon pea and 45.48 and 44.56 in chickpea, respectively. The overall disease reduction was recorded 43.74% in pulse crops. The yield parameter reflected significantly more over district, state and national level productivity in pigeon pea and chickpea crop. Wide yield gap of both pulse crops also indicated that farmers should adopt latest production technologies with high yielding varieties and integrated plant protection components will subsequently change this alarming trend of galloping yield gap. Average gross returns and net returns of demonstration in pigeon pea and chickpea crops were 39.49 and 56.21% and 53.99 and 91.83% higher than the farmers' practices respectively. Average benefit cost ratio was found higher throughout the study in pigeon pea and chickpea i.e. 3.34 and 3.01 respectively. 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 pulse crops.

**Keywords**: Disease and pest reduction, Impact on yield and economics, IPM strategies, Pulses, Yield gap

Pulses are an important source of dietary protein for human and animal because of their richness with proteins (ranging from 20–24%), 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, their 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 and producing 23.15 million tonness of pulses from 28.34 million hectares area with the average productivity of 817 kg/ha (Agricultural Statistics at a glance 2020). The average productivity of pulses in Uttar Pradesh was about 1033 kg/ha in 2019–20 (Agricultural Statistics at a glance 2020).

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 and heavy infestation of biotic stresses i.e. wilt, collar rot and pod borer at different crop growth stages of pigeon pea and chickpea. The wilt and collar rot diseases cause 10% seedling mortality in pigeon pea and chickpea (Sharma *et al.* 2015) and incidence of pod borer, if not controlled, can cause 70% yield losses alone discourage farmers to grow pulse crops (Sharma *et al.* 2016, Kumar, *et al.* 2019). 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. To overcome the present crisis, the farmer to be paid more attention to integrated approach for pest management. Keeping this in view, recommended production technologies with integrated pest management (IPM) strategies of pulse crops were conducted under cluster front line demonstrations programne for sustainability of production and farmers income.

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## MATERIALS AND METHODS

Mahayogi Gorakhnath Krishi Vigyan Kendra, Gorakhpur had conducted the cluster front line demonstrations on pulse crops during *kharif* and *rabi* 2017–18 to 2019–20. The Krishi Vigyan Kendra had organized 213 and 60 cluster frontline demonstrations on pigeon pea and chickpea in an area of 85.20 and 22.15 ha respectively in the six blocks of Gorakhpur district, viz. Jungle Kaudiya, Campierganj, Pali, Bhathat, Chargawan and Khorabar. 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, viz. NA 2, IPA 203 and GNG 1581, RVG 202 respectively and demonstrated with full package of practices on 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 as;

Percent increase in yield (%) = Yield gain in IT plot (q/ha) - Yield gain in EP plot (q/ha)/Yield gain in EP plot (q/ha) ×100

Insect-pest and disease incidence (%) = Number of infected plant unit/Total no. of plant unit (healthy + infected) ×100

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 1) were estimated as:

$$\text{Yield Gap I} = [(Y_P - Y_D)/Y_P] \times 100$$

$$\text{Yield Gap II} = [(Y_D - Y_F)/Y_D] \times 100$$

Where $Y_P$, potential yield; $Y_D$, demonstration plot yield; $Y_F$, existing farmer's yield.

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

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

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

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

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

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

## RESULTS AND DISCUSSION

*Impact of recommended production technologies with IPM strategies on insect-pest/disease reduction and yield of pulse crops*: The performance of improved package and practices was found most effective in controlling least number of affected plants/m$^2$ as well as least number of pods/plants (Table 1). The average per cent reduction in affected plant/m$^2$, per cent reduction in affected pod/plant and reduction in collar rot/wilt incidence were recorded 45.92, 40.42 and 43.47% in pigeon pea and 45.48, 43.85 and 44.00% in chickpea, respectively. The average yield was 14.29 q/ha and 16.91 q/ha in pigeon pea and chickpea under demonstrated plots respectively as well as in control plot average yield was 10.18 q/ha and 11.41 q/ha, respectively. This showed that there was a positive and significant increase in the average crop wise yield of pigeon pea and chickpea in demonstration plots over the farmers practice by 40.79 and 48.12% respectively. The increase in percentage of yield was ranging between 36.70–43.14 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 the enhanced yield of pulses in demonstrated area. The similar trends of yield enhancement in front line demonstration of pulse crops have been documented by Dwivedi *et al.* (2013) and Singh *et al.* (2020).

*Impact of recommended production technologies 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 and weed management. The proper plant protection measures were used as per package and practices in pulse crops. The yield parameters were also compared at district, state and national level productivity. The result clearly indicated that the average pigeon pea productivity was recorded as 14.29 q/ha from demonstrated plot. The highest average pigeon pea productivity i.e. 14.64 q/ha received during 2017–18 followed by 14.20 and 14.04 q/ha in 2019–20 and 2018–19 respectively. The demonstrated technology of pigeon pea yielded average productivity by 152.15, 31.45 and 67.99% more over district, state and national yield, respectively. Singh *et al.* (2015) also reported similar findings in chickpea under crop cafeteria during 2014–15 crop seasons. Similar findings have also been reported by Singh *et al.* (2020) in chickpea crop.

The results of demonstrated technologies of chickpea (Table 1) shows that chickpea yielded average productivity 16.91 q/ha from demonstrated plot. The maximum average productivity was 18.16 q/ha in 2018–19 and lowest was

Table 1 Impact of improved technology with IPM strategies on insect-pest/disease reduction, productivity enhancement and yield gap

| Crop | Year | Average yield (qt/ha) | | Impact on yield (%) | % pod borer reduction affected plant/ $m^2$ | % pod borer reduction affected pod/ plant | % reduction collar rot/wilt incidence | % Impact change over EP | % Impact change over DY | % Impact change over SY | % Impact change over NY | Yield gap I (%) | Yield gap II (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *DP | EP | | | | | | | | | | |
| Pigeon pea (*Kharif*) | 2017–18 | 14.64 (12.44-16.23) | 10.27 | +42.55 | 50.50 | 42.75 | 46.50 | +42.55 | +171.11 | +24.07 | +52.50 | 47.71 | 29.85 |
| | 2018–19 | 14.04 (13.10-18.40) | 10.27 | +36.70 | 45.25 | 38.50 | 42.30 | +36.70 | +122.86 | +39.29 | +82.81 | 49.86 | 26.85 |
| | 2019–20 | 14.20 (11.75-17.50) | 10.00 | +43.14 | 42.00 | 40.00 | 41.60 | +43.14 | +162.48 | +30.99 | +68.65 | 27.14 | 29.58 |
| Total/Average | | 14.29 (12.43-17.38) | 10.18 | +40.79 | 45.92 | 40.42 | 43.47 | +40.79 | +152.15 | +31.45 | +67.99 | 41.57 | 28.76 |
| Chickpea (*Rabi*) | 2017–18 | 16.95 (15.65-18.30) | 11.88 | +42.67 | 52.00 | 42.86 | 48.80 | +42.67 | +58.41 | +46.12 | +59.45 | 29.38 | 24.33 |
| | 2018–19 | 18.16 (16.80-20.60) | 11.50 | +57.91 | 44.44 | 44.83 | 40.60 | +57.91 | +21.07 | +42.99 | +89.96 | 35.14 | 36.67 |
| | 2019–20 | 15.61 (11.40-18.00) | 10.86 | +43.77 | 40.00 | 46.00 | 42.60 | +43.77 | +46.57 | +13.86 | +39.87 | 44.25 | 30.43 |
| Total/Average | | 16.91 (14.62-18.97) | 11.41 | +48.12 | 45.48 | 44.56 | 44.00 | +48.12 | +42.02 | +34.32 | +63.06 | 36.26 | 30.48 |
| Overall Total/Average | | 15.60 | 10.80 | +44.46 | 45.70 | 42.49 | 43.74 | +44.46 | +97.09 | +32.89 | +65.53 | 38.92 | 29.62 |

Demo.= Demonstration; DP= Demonstrated Plot; EP= Existing practice; DY= District yield; SY= State yield; NY= National yield.

*Figures in parentheses indicate lowest and highest yield of demonstrated farmer. Source of district, state and national yield data for calculation of impact and yield gap: Directorate of Economics and Statistics, 2020 and Food and Agriculture Organization Corporate Statistical Database, 2021.

15.61 q/ha in 2019–20. The demonstrated technology of chickpea gave average productivity by 42.02, 34.32 and 63.06% more over district, state and national yield, respectively.

*Impact of recommended production technologies 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 results, 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 1). The average yield gap I and II was recorded 41.57 and 28.76% respectively in pigeon pea and 36.26 and 30.48% in chickpea, respectively. These findings are in corroboration with the findings of Mondal (2011) and Sultana *et al.* (2019).

Yield gap of different crops was also analyzed with average yield of district, state and national (Table 1) and wide yield gap was observed in pigeon pea and chickpea crops during study period. It 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 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 recommended technologies with IPM strategies. These finding are in corroboration with the findings of Singh *et al.* (2012) and Raj *et al.* (2013).

*Impact of recommended production technologies 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 2. 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 ₹2103.33/ha and ₹2769.33/ha was made under demonstration of pulses for pigeon pea and chickpea, respectively. The average cost of cultivation increased by 11.59% and 13.05% 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. ₹77691.67/ha followed by pigeon pea ₹76200/ha. The average net return of demonstration for pigeon pea was ₹53167.67/ha as compare to farmers practices of ₹34037.67/ha whereas in chickpea average net return was ₹51088/ha as compared to farmers practices of ₹26790.67/ha. The study found average additional net returns of ₹19130/ha

Table 2 Impact of improved technology with IPM strategies on economics of pulse crops under real farm situation

| Crop | Year | CoC (₹/ha) | | CoC increase over FP (%) | GMR (₹/ha) | | GMR increase over FP (%) | NR (₹/ha) | | NR increases over FP (%) | ACoC in IT (₹/ha) | ANR (₹/ha) | BCR | | ICBR | Effective gain (₹/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 |
| | 2019–20 | 27650 | 24200 | 14.26 | 85200 | 61200 | 39.22 | 57550 | 37000 | 55.54 | 2450 | 20550 | 3.08 | 2.52 | 8.39 | 18100 |
| Average | | 23032.33 | 20595.67 | 11.59 | 76200 | 54633.33 | 39.49 | 53167.67 | 34037.67 | 56.21 | 2103.33 | 19130 | 3.34 | 2.69 | 10.05 | 16960 |
| 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 |
| | 2019–20 | 34580 | 32150 | 7.56 | 85855 | 58355 | 47.13 | 51275 | 26205 | 95.67 | 2430 | 25070 | 2.48 | 1.81 | 10.32 | 22640 |
| Average | | 26603.67 | 23834.33 | 13.05 | 77691.67 | 50625 | 53.99 | 51088 | 26790.67 | 91.80 | 2769.33 | 24297.33 | 3.01 | 2.21 | 10.27 | 21528 |

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.

and ₹24297.33/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 39.49% and 53.99% in pigeon pea and chickpea 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 (Table 2) 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 ₹16960/ha and ₹21528/ha from pigeon pea and chickpea, respectively whereas average benefit cost ratio was recorded by 3.34 and 3.01 from demonstration plots of pigeon pea and chickpea respectively while it was received by 2.69 and 2.21 from farmers' practice. The average incremental cost benefit ratio was 10.05 and 10.27 in pigeon pea and chickpea respectively, indicating a good return of each additional rupee invested on improved technologies in all the pulse crops separately. Similar findings were also reported in frontline demonstrations on pulse crops by Dwivedi *et al.* (2014) and Rachhoya *et al.* (2018).

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