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# Yield gap and economic analysis of cluster frontline demonstrations (CFLDs) on pulses in Eastern Himalayan Region of India

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## Abstract
The study aimed at assessing the performance of cluster frontline demonstrations (CFLDs) in terms of grain yield, extension gap, technological gap and economic gains in pulse crops in 21 selected districts of Manipur, Meghalaya, Mizoram, Nagaland and Tripura during 2017-18 to 2019-20. The data on selected parameters of demonstration plots as well as control plots were collected through experimental designs (‘Control-Treatment’) of social research. The results reveal that the average grain yield in demonstration fields of all selected pluse crops namely; field pea, black gram and lentil was higher than farmers practice. The PU 31 variety of black gram was recorded with the lowest extension gap (2.34q/ha), technology gap (0.60 q/ha) and technology index (6.74%) followed by lentil (HUL 57) with 2.58q/ha, 5.74 q/ha and 40.97% and field pea (Aman) with 3.08q/ha, 9.17q/ha and 41.67% respectively. The highest additional income (Rs. 24422/ha) in CFLD over local check was recorded in cultivation of black gram followed by lentil (Rs. 16284/ha) and field pea (Rs. 16109/ha). The results clearly indicate that the use of improved varieties and package of cultivation practices with scientific intervention under cluster frontline demonstration programme contributes to increase the productivity and profitability of pulses in the region by reducing the yield and technology gaps.

**Keywords:** Pulses, yield gap, technology gap, extension gap, technology index, KVK

## Introduction
Pulses are the important sources of proteins, vitamins and minerals and are popularly known as “Poor man’s meat” and “rich man’s vegetable”, which contribute significantly to the nutritional security of the country. Besides, pulses possess several other qualities such as they improve soil fertility and physical structure, fit in mixed/inter-cropping system, crop rotations and dry farming and provide green pods for vegetable and nutritious fodder for cattle as well. India is the largest producer (26%) of world’s production and consumer (30%) of total pulses of the world. The frequency of pulses consumption in the country is much higher than any other source of protein, which indicates the importance of pulses in their daily food habits (Raj *et al.* 2013) [6]. The domestic production of about 23 million tonnes during 2016-17 shall be still less than the future estimated demand of 29-30 million tonnes. The targeted production and productivity is possible by way of harnessing this yield gap by growing pulses in new niches, precision farming, quality inputs, soil test based INM and mechanized method of pulse cultivation complimented with generous governmental policies and appropriate funding support to implementing states/stake holders (Tiwari and Shivhare, 2017) [12]. According to the Vision-2030 document prepared by the ICAR-Indian Institute of Pulses Research (IIPR), Kanpur, a growth rate of 4.2% has to be ensured in order to meet the projected demand of 32 million tonnes of pulses by 2030. This will, however, require a paradigm shift in research, technology generation and dissemination, popularization of improved crop management practices and commercialization along with capacity building of the stakeholders in frontier areas of research (Tiwari and Shivhare, 2017) [12].

In India, pulses, therefore, have always received due attentions both in terms of requirement by consumers and adequate programmatic support from the government at the production front. Addressing this concern of significance, the Ministry of Agriculture and Farmers Welfare, Govt. of India had initiated a nation-wide cluster frontline demonstration (CFLD) programme on pulses under National Food Security Mission-Pulses (NFSM-Pulses) since 2015-16. The basic strategy of the Mission is to promote and extend improved technologies, i.e., seed, micro-nutrients, soil amendments, integrated pest management, farm machinery and implements, irrigation devices along with capacity building of farmers.

The ICAR through its Krishi Vigyan Kendras (KVKs) across the country has been implementing this CFLD programme on different pulse crops to boost the production and productivity of pulses with improved varieties and location specific technologies.

Despite great scope and better opportunities for pulses production in Northeast region of India (including the niche areas of rice fallow), the growth rate is low due to many intricate and interrelated factors right from soil/climate related constraints to technological and extension oriented tribulations. Besides, shrinkage in land holding, growing population pressure, increasing food/pulse demand and poor soil health are the key constraints (Praharaj*et al*. 2018)[5]. The major pulses grown in the region are green gram (*Vigna radiata*), black gram (*V. mungo*), pigeon pea (*Cajanuscajan*), cowpea (*V. unguiculata*), french bean (*Phaseolus vulgaris*), chickpea (*Cicer arietinum*), lentil (*L. culinaris)* and field pea (*Pisum sativum*). In hills, other beans such as faba bean (V. *faba*), adzuki bean (*Vigna angularis*), moth bean (*V. aconitifoloia*) and broad bean (*Dolichos lablab*) are also used as pulses. The Krishi Vigyan Kendras (KVKs) in this region have been successfully implementing this programme since rabi 2017-18 by conducting cluster frontline demonstrations in a systematic manner on farmers' field under the close supervision of their scientists to show the worth of new/ proven varieties with technological packages in their respective districts for enhancing production and productivity of pulse crops. With this background, the present investigation was undertaken with the specific objectives to assess the performance of CFLD on pulses in terms of grain yield, extension gap, technological gap and economic gains by the farmers so that the findings the study will be helpful to the concerned policy makers and other stakeholders to focus on the way forward for improving pulses production in the region, vertically and horizontally as well.

## Materials and Methods

**The study sites:** The study was carried out in 5(five) states of Eastern Himalayan Region of India namely; Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Only those KVKs (21 nos.) which had implemented CFLD programmes on selected varieties of rabi pulses namely; field pea, black gram and lentil during last three years (2017-18 to 2019-20) were selected for the study. One variety of each crop namely; Aman (field pea), PU 31 (black gram) and HUL 57 (lentil) which was having paramount significance in terms of production potential and wide acceptance by the farmers in their local farming systems were considered for the study.

## Experimental details

All the technological interventions were taken as per prescribed packages of practices for selected varieties of field pea, black gram and lentil (Table 1) by the KVKs of the region. The awareness programmes for the farmers including trainings were organized by the Scientists of KVKs as part of technological interventions with improved package of practices in demonstration plots at farmers' fields. The farmer practice was considered as control plot/local check which was maintained by the farmers according to their own traditional cultivation practices with old varieties. The KVKs as per the mandate of the project had provided critical inputs such as seeds, fertilizers, IPM, implements and bio-fertilizers to the farmers for demonstration plots with technical support. The necessary steps for selection of site, selection of farmers, layout of demonstrations etc were followed as suggested by Choudhary (1999) [1]. The KVKs Scientists used to visit to the cluster frontline demonstrations fields and farmer's field (control) on regular basis for close supervision and data collection during the entire process of demonstration programme. The study was conducted in experimental designs ('Control-Treatment') of social research.

**Table 1:** Details of recommended package of practices for field pea, black gram and lentil

| Technological intervention | Recommended packages of Practice followed in CFLDs | | |
|---|---|---|---|
| | **Field pea (*Pisum sativum)*** | **Black gram (*Vigna mungo*)** | **Lentil (*Lens esculenta*)** |
| Variety | Aman | PU 31 | HUL 57 |
| Seed rate | 70 kg/ ha | 25 kg/ha | 80kg/ha |
| Seed treatment. | Rhzobium culture @ 50g/kg seed, Bavistin @ 2g/kg seed and Trichoderma viride @ 4g/kg seed. | Seed treatment with rhizobium culture and Phosphate Solubilising Bacteria @ 50 g/kg seed, Trichoderma viride @ 5 g/kg seed. | Seed treatment with rhizobium culture and Phosphate Solubilising Bacteria @50 g/kg seed, Trichoderma viride @ 5 g/kg seed, Seed Priming in lentil. |
| Sowing method/Spacing | Line sowing @ 30cm X 10 cm with minimum tillage | Row to row 30-35 cm and plant to plant 10 cm | Line sowing @ 30cm X 10cm. |
| Time of Sowing | November-December | Mid August- Mid September | Mid October-1st week of November |
| Nutrient management | Application of vermicompost @ 5q/ha, 65.5 kg/ha of lime as soil amendment, nutrient complex Tricontanol @ 0.75 l/ha and Bowax @ 10kg/ha. Basal fertilizer application *viz*. 25kg N, 50kg $P_2O_5$ and 25kg $K_2O$. | Vermicompost @ 1.5 t/ha and 65.5 kg/ha of lime as soil amendment. Integrated Nutrient Management with 25 kg N, 50 kg $P_2O_5$ and 25 kg $K_2O$. | Application of NPK @ 10:35:0 kg/ha along with application of micronutrient mixture @ 7.5 kg/ha, Neem oil @ 2.6 lt. /ha and nutrient complex Tricontanol (Vipul) @ 52.5 lt. /ha. |
| Weed management | Application of glypohosate @ 5 ml/litre water at least 10 days prior to sowing of field pea. | 2-3 intercultural operation or hand weeding during 3-5 weeks after sowing is recommended. | One weeding 30-40 days after sowing or use of weedicide (Pendimethalin @1.0 kg/ha) immediately after sowing helps in controlling weeds. |
| Insect-pests and disease management. | Seed treatment with Carbendazim @ 2 g/kg against infestation of powdery mildew. | Seed treatment with Mancozeb and Carbendazim @2 g/kg. Spraying with Chloropyriphos 20 EC against infestation of leaf eating caterpillar. | The major diseases of lentil are rust and wilt. Use of resistant varieties is helpful in controlling the disease. Pests are not a major problem in lentil. In case of aphid infestation, spraying of Monocrotophos (0.04%) is effective |

**Data collection and analysis**

The data on selected parameters of demonstration plots as well as control plots were collected on regular basis and continued till harvesting of crops to assess the overall performance of CFLDs on selected pulse crops. The structured interview schedule was also used to elicit the information from beneficiary and non-beneficiary farmers about adoption pattern, varietal replacement and area increase in villages of pulse crops etc. The triangulation of data was made with the interaction of state agriculture officials and secondary data available with the departments. The data outputs were also collected from CFLD plots as well as control plots and finally the extension gap, technology gap, technology index, additional return along with the benefits-cost ratio were worked out (Table 3 & 4) as per the formula adopted by (Samui *et al*. 2000) [8] as given below:

Extension Gap = Demonstrated yield-Farmers' practice yield
Technology Gap= Potential yield- Demonstration yield
Additional Return = Demonstration return – Farmers practice return

$$\text{Technology Index} = \frac{\text{Potential yield-Demonstration yield}}{\text{Potential yield}} \times 100$$

$$\text{Benefit-cost ratio} = \frac{\text{Gross return}}{\text{Gross cost}}$$

The basic information from the farmer's field as well as feedback information were systematically recorded and analyzed to see the comparative performance of cluster frontline demonstrations (CFLDs) and farmer's practice (control).

**Results and Discussion**

The year-wise details of demonstrations conducted by Krishi Vigyan Kendras in the region are presented in Table 2. In each cluster frontline demonstration (CFLD), one suitable variety of each pulse crop namely; Aman (Field pea), PU 31 (Blackgram) and HUL 57 (Lentil) was considered along with their recommended package of practices. While in control/ local check plots, locally available old variety of select pulse crops with traditional cultivation practices was followed by the farmers in their local farming situations. A total of 2063 demonstrations on improved varieties of field pea (862), black gram (604) and lentil (597) covering 1101 ha were conducted by the KVKs at farmers' field during 2017-18 to 2019-20 (Table 2 & 3).

**Table 2:** Details of pulses growing under Cluster frontline demonstrations (CFLDs) and farmers practices

| Pulse | Variety | | 2017-18 | | 2018-19 | | 2019-20 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CFLD | Farmer Practice | Area (ha.) | No. of farmers | Area (ha.) | No. of farmers | Area (ha.) | No. of farmers | Area (ha.) | No. of farmers |
| Field pea | Aman | Local | 140 | 285 | 190 | 517 | 110 | 378 | 440 | 1180 |
| Blackgram | PU 31 | Local | 140 | 343 | 80 | 483 | 50 | 220 | 270 | 1046 |
| Lentil | HUL 57 | Local | 130 | 308 | 107 | 366 | 154 | 491 | 391 | 1165 |
| Total | - | - | 410 | 936 | 377 | 1366 | 314 | 1089 | 1101 | 3391 |

**Grain yield and gap analysis of pulse crops**

The grain yield and gap analysis of pulse crops in demonstrated field's and farmer's practice is presented in Table 3. Data presented in the table reveals that average grain yield of all the three pulses *viz*; field pea, black gram and lentil in demonstration fields was higher than that of farmer's practice. Vittal*et al*. (2005) [14] also supported that yield in frontline demonstrations was better than that of farmer practices. The results show that average grain yield of field pea (var. Aman) under cluster frontline demonstrations was 12.83 q/ha compared to 9.75 q/ha in farmers practice with 31.74% average increase over local check. In case of black gram (var. PU 31), average yield of 8.39q/ha in demonstration plot was recorded against 6.05q/ha in farmers' practice with average increase of 38.67% over local. While 8.26q/ha average yield was found in CFLD against 5.68q/ha in farmers' practice accounting 47.28% increase yield over the local check in lentil (var. HUL 57). The results clearly indicate the positive effects of CFLDs over the existing practices toward enhancing the yield of pulses in the region with its positive effect on yield attributes. The above findings are in accordance with Singh *et al.* (2018) [10], Mitnala*et al*. (2018) [4] and Saikia*et al*. (2018) [7].

**Table 3:** Productivity, extension gap, technology gap and technology index of pulses under CFLDs(average over years)

| Pulse | No. of demons | Area (ha) | Average productivity (q/ha) | | | % increase over FP (check) | Extension gap (q/ha) | Technology gap (q/ha) | Technology Index (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Potential | CFLD | FP | | | | |
| Field pea | 862 | 440 | 22 | 12.83 | 9.75 | 31.74 | 3.08 | 9.17 | 41.67 |
| Blackgram | 604 | 270 | 9 | 8.39 | 6.05 | 38.67 | 2.34 | 0.60 | 6.74 |
| Lentil | 597 | 391 | 14 | 8.26 | 5.68 | 47.28 | 2.58 | 5.74 | 40.97 |
| Average | 679 | 367 | 15 | 9.83 | 7.16 | 39.23 | 2.67 | 5.17 | 29.79 |

FP=Farmers practice

The per cent increment in yield of pulses to the extent of 31.74 in field pea, 38.67 in black gram and 47.28 in lentil CFLDs over the farmers practice created greater awareness and motivated the other farmers to adopt the improved package of practices of pulses. These demonstrations also built the relationship and confidence between farmers and scientists. The beneficiary farmers of CFLDs also played an important role as source of information and quality seeds for wider dissemination of the high yielding varieties of pulses for other nearby farmers.

The data presented in Table 3 also disclose that PU 31 variety of black gram was recorded with the lowest extension gap (2.34q/ha), technology gap (0.60 q/ha) and technology index (6.74%) compared to other pulse crops under study. This was followed by lentil (HUL 57) with 2.58q/ha extension gap, 5.74 q/ha technology gap and 40.97% technology index.

While field pea (Aman) emerged with the highest extension gap (3.08q/ha), technology gap (9.17q/ha) and technology index (41.67%) respectively. This emphasized the need of KVKs to educate the farmers more particularly those non-beneficiaries through various extension means for the adoption of scientific practices in cultivation of all the pulse crops.

**Economics analysis of pulse crops**

Table 4 depicts the results of economic analysis of cluster frontline demonstration on pulse crops conducted by KVKs. It is seen from the table that the total average return from recommended practice (CFLD's) was Rs. 84098 /ha as compared to Rs. 60714 /ha in farmers practice in case of field pea (var. Aman) during the period of study. This yielded additional net profit of Rs. 45166 in demonstration and Rs. 29057/ha in farmers practice. While average gross return of Rs. 91861/ha was recorded in black gram (var. PU 31) in demonstration field against Rs. 50200 /ha in farmers practice which could provide net returns of Rs. 47600 and Rs. 23178 /ha accounting Rs. 24422 as additional profit due to CFLD in farmers' field. While Rs. 86514/ha was the gross return of lentil (var. HUL 57) in CFLD by using improved cultivation practices compared to Rs. 53371/ha in farmers' field with traditional cultivation practices. The net return of Rs. 34734/ha and Rs. 18450/ha were recorded in demonstration and farmers practice respectively yielding an additional profit of Rs. 16284/ha due to CFLD on lentil. The findings are in conformity with those of Singh *et al*. (2019)[11]. Raj *et al.* (2013)[6] in their study on impact of FLD on yield of pulses also reported that the improved technology gave higher gross return, net return with higher benefit cost ratio as compared to farmer's practices. Similar findings were reported by Singh *et al*. (2017)[9] in their study on impact analysis of frontline demonstrations on pulses in Punjab.

**Table 4:** Economics of cluster frontline demonstrations on pulses under CFLDs (average overyears)

| Pulse | Gross returns(Rs./ ha) | | Gross cost(Rs./ ha) | | Net return(Rs./ha) | | Additional gain (Rs./ha) in FLD's | B:C ratio | |
|---|---|---|---|---|---|---|---|---|---|
| | CFLD | FP | CFLD | FP | CFLD | FP | | FLD | FP |
| Field pea | 84098 | 60714 | 38933 | 31657 | 45166 | 29057 | 16109 | 2.18 | 1.91 |
| Blackgram | 91861 | 50200 | 44260 | 27022 | 47600 | 23178 | 24422 | 2.10 | 1.85 |
| Lentil | 86514 | 53371 | 49054 | 34921 | 34734 | 18450 | 16284 | 1.79 | 1.53 |
| Average | 87491 | 54762 | 44082 | 31200 | 42500 | 23562 | 18938 | 2.02 | 1.76 |

FP=Farmers practice

The results in Table 3 also clearly show higher benefit cost ratio (B:C ratio) of recommended practices in demonstration plots than control plot in all the pulse crops under the study. This may be due to higher yields obtained under improved technologies compared to local check (farmers practice). The findings are in the line of that of the study conducted by Udhad*et al.* (2019)[13]. The B:C ratio recorded higher in recommended practice with 2.18, 2.10 and 1.79 in field pea, black gram and lentil as compared to 1.91, 1.85 and 1.53 in farmer's practice of the same crops. These results in accordance with the findings of Mitnala*et al*. (2018)[4], Gurumukhi and Mishra (2003)[3], Dhaka *et al.* (2010)[2] and Singh *et al.*, (2018)[10]. Hence, favourable benefit cost ratios proved the economic viability of the interventions and convinced the farmers on the utility of interventions. The programme of large scale cluster frontline demonstrations could be popularized for other pulses crops as well in order to increase farmers' income and to attain self sufficiency in pulses production in the region.

**Conclusion**

The findings above revealed that all the selected varieties of pulses namely; Aman (field pea), PU 31 (black gram) and HUL 57 (lentil) gave higher yield in recommended practice (CFLD's) than farmers practice in all the five states of the Eastern Himalaya region of India. There is a wide yield gap between research station technology and farmers' technology, which has resulted in lower yields in farmers' practices. The research station technology has the potential of doubling production at national level without increasing area under pulses if farmers adopt the recommended package of practices. The extension agencies should demonstrate effects of new technology in pulses production and motivate farmers for adoption of new technology to bridge this wide yield gap. Economic analysis on different parameters also revealed that net returns and additional gains were recorded higher in recommended practice (CFLD's), which implies that the CFLD programme is an effective tool for increasing the production and productivity of pulses and changing the knowledge, attitude and skill of farmers. The study calls for reducing the extension and technology gaps in these states through state specific research and extension programs. KVKs in this region have significant role to play towards effective transfer of improved pulses cultivation practices to farmers through their mandated activities including skill oriented training and other extension programmes with proper technical support. Farmers' awareness on improved technology through different innovative extension approaches including ICTs, FPOs, CIGs, FIGs, farmers' fairs/field days etc. as well as quality seed availability of improved varieties are the key factors in increasing productivity of pulses. The identified yield enhancing technology needs to be subsidized for wider adoption among the farmers in their local farming systems and enhancing production and productivity of pulse crops in the region.

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