Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2023, Volume 36, Issue 1, Page 14-19

Impact of front line demonstrations on the production and productivity of lentil (*Lens culinaris*) in Assam, India

M. Thoithoi Devi • Bagish Kumar* • R.M. Bordoloi • Sampurna Sharma • A.K. Tripathi • V.P. Chahal

ICAR-Agricultural Technology Application Research Institute, Zone-VI, Guwahati, Assam, India

ARTICLE INFO

Article history:
Received: 28 November, 2022
Revision: 13 January, 2023
Accepted: 05 May, 2023

Key words: *Front Line Demonstrations, Lentil, Potential yield, Technology index*

DOI: 10.56678/iahf-2023.36.01.3

ABSTRACT

Pulses are staple protein food item for India's vegetarian and rural population to ensure nutritional security. Lentil (Lens culinaris) is one of the oldest pulse crops and most nutritious among the rabi pulses. Assam is the major state where pulses occupy 146.6 thousand hectares with an annual production of 107.5 thousand tonnes and a productivity of 733 kg/ha during 2016-17. Lentil is one of the major crops of the state during rabi. A study was conducted under cluster frontline demonstration programme on pulses to study the yield gap in lentil crop in the state for three consecutive years i.e. from 2017-18 to 2019-20. The study revealed that there was a yield gap between demonstration yields and local check. On the basis of three years data, it was observed that demonstration yield was 47 % higher than local check or farmers practices. Technology yield gap in lentil was highest (6.7 q ha-1) during 2018-19 while lowest (5.8 q ha-1) during 2017-18. Extension yield gap varied to the extent of 1.7 to 3.0 q ha-1 in lentil. Benefit-cost ratio in demonstration plots varied between 1.72 to 2.23 with highest benefit-cost ratio during 2017-18 and lowest in 2018-19 owing to variable performance of lentil over the years. Overall, it is inferred that improved farm technology has great potential in enhancing the lentil productivity and profitability through frontline demonstration programme in Assam.

1. Introduction

Pulses share the significant amount in agricultural GDP next to food grains (Choudhary, 2009). The nutritional composition of edible pulses makes them highly preferable among the vegetarians (Adsule et al., 1989; Reddy, 2010; Raj et al. 2013; Ali and Gupta, 2012; Kokate et al. 2013). The statistics of pulses in India indicates that, they are the largest producer, consumer and importer of pulses in the world, accounting for about 25% of global production, 27% of consumption, and 34% of food use (F.A.O., 2016; Singh et al., 2020; Gregory, et al. 2003). Despite its natural ability for improving soil fertility & natural resource management, they were grown on the marginal land with minimum or no inputs in India due to its competition with cereals which limits its production potential and hamper the productivity; subsequently the pulses were imported for fulfilling the domestic requirement (Joshi, 1998; Ahlawat *et. al.*, 2016; Joshi and Saxena, 2002; Srivastava et al., 2010; Lingareddy, 2015; Ramasamy and Selvraj, 2002; Praharajet al. 2018; Ali and Kumar, 2006). A wide range of pulses were grown in the country during both *kharif* & *rabi* season *viz;* chickpea, black gram, red gram (pigeon pea), green gram (mungbean), lentil and so on. Amongst the various pulses lentil (*Lens culinaris*) is one of the oldest pulse crops and most nutritious among the *rabi* pulses. India ranks first in the world in respect of production as well as acreage in lentil however, the average productivity is significantly poor being only 714 kg/ha below the world average of 1008 kg/ha (Ahmad *et. al,* 2012). The lentil is grown throughout the country. As far as northeast India is concerned, Assam is the major state where pulses occupy 146.6 thousand hectare with an annual production of 107.5 thousand tonnes and productivity of 733 kg/ha during 2016-17 (Barman *et. al.,* 2020, Agri vision, 2021). Lentil and peas are the major crops of the state during *rabi* (Praharaj *et. al.*, 2018). In Assam, introduction of pulses like lentil in rice fallows can augment the domestic availability of pulses which are in short supply and also help in restoration of the soil health (Singh and Satapathy, 2019). The Cluster

*Corresponding author: bagishars@gmail.com

Frontline Demonstration programme (CFLDs') in pulses is a unique programme started by Ministry of Agriculture & Farmers' Welfare, Govt. of India, conducted under close supervision of agricultural 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). It has been reported that there is a scope of increasing area under lentil during the *rabi* season, as its production cost per hectare is less with higher net returns than the competing crops like wheat, gram and mustard in water-deficit and resource-poor conditions. (Singh and Singh, 2014). Krishi Vigyan Kendra (KVKs), a vast network of ICAR in the country, can play an important role in demonstrating the improved crop production technologies in farmer's fields and multiplication of seeds (Mandal *et. al.,* 2017). Krishi Vigyan Kendras in Assam has introduced the high yielding variety (KLS-218) of lentil in various districts of the state. Frontline demonstrations on lentil were conducted in an area of 20.76 ha, 25 ha, and 16.66 ha the state during 2017-18, 2018-19, 2019-20 respectively. The aim of this study was to demonstrate the transfer of generated farm technology through CFLDs in rainfed lentil production systems with the goals of increasing productivity, profitability, and closing yield gaps. In this article, technological and extension yield gaps of lentil were presented for framing an acceptable extension strategy for successful technology transfer to target farmers in Assam.

2. Materials and methods

Cluster Frontline Demonstrations on improved farm technology of lentil (Table 1) were conducted by Krishi Vigyan Kendras in Assam during 2017-18 to 2019-20 under rainfed conditions on 62.42 ha area of the state. In CFLD plots, practices like recommended seed rate, insect pest and disease management, etc. were adopted whereas, in the adjoining farmers' fields, crop was grown as per the practices followed by the farmers which served as control / local check (Table 1). The primary data on grain yield, farmers' practices etc. were collected from the beneficiary farmers via personal interviews. The yield increase in demonstrations over farmers' practice was calculated by using the following formula:

$$\%\text{ Yield increase over farmers' practice} = \frac{(\text{Demonstration average plot yield} - \text{farmers average plot yield})}{\text{Farmers average plot yield}}$$

Estimation of technology gap, extension gap, technology index: The estimation of technology gap, extension gap, and technology index was done using

following formula (Kadian *et.al.* 1997; Samui *et. al.* 2000):

i) **Technology gap** = Potential yield-Demonstration plot average yield
ii) **Extension gap** = Demonstration plot average yield - Farmer's plot average yield
iii) **Technology Index** $= \frac{(\text{Pi}-\text{Di})}{\text{Pi x 100}}$

Where, Pi: Potential yield of i^{th} crop, Di: Average demonstration plot yield of i^{th} crop

Economic analysis of Cluster Front Line Demonstration's on lentil: Cost of cultivation of lentil include cost of inputs like seeds, fertilizers, pesticides etc. purchased by the farmers (in farmers' practice) /supplied by the Krishi Vigyan Kendra (in demonstration plots) as well as hired labour (if any), sowing charges, charges of land preparation, intercultural operations, post-harvest operation etc. The farmers' family labour was not taken into consideration in the present study. The gross return was worked out by taking price of grain yield. Similarly, the Benefit-Cost-Ratio (BCR) was worked out as a ratio of gross returns to costs of cultivation.

Table 1. Detail of demonstrated technologies under CFLDs and farmers practices in lentil

Lentil	Demonstrated technology	Farmers practice
Variety	KLS-218	Local
Seed Rate	40 kg/ha	60 kg/ha
Sowing Method	Line sowing	Broadcasting, deep sowing
Fertilizer Dose	Use of vermicompost@1 t/ha	Nil
Plant Protection	Incorporation of *Trichoderma viridae* @ 5 kg/ha	Nil
Technical guidance	Time to time	Nil

3. Results and discussion

Grain yield

Data presented in table 2 & figure 1 revealed that transfer of improved farm technology under CFLDs in lentil resulted in invariably higher grain yield (7.3 to 8.2 q ha^{-1}) than farmers' plot yield (5.1 to 5.6 q ha^{-1}), which may be attributed to the adoption of recommended agro technologies in demonstration plots. Sagar and Chandra (2004), Sharma *et. al.* (2012) and Choudhary (2009b) has also reported yield enhancement by the use of recommended agro-technologies under CFLDs'. This study indicate that with the adoption of improved farm technologies in lentil variety KLS-218, the productivity increased from 5.2 to 8.2 q ha^{-1} with 57.69% increase in yield over farmers plot during 2017-18, 5.6 to 7.3 q ha^{-1} with 30.36% increase in yield over farmers plot during 2018-19, 5.1 to 7.8 qha-1 with 52.94% increase in yield over farmers plot during 2019-20 with adoption of improved technologies (Table 2). The yield enhancement through adoption of improved farm technology under CFLDs' has also been reported in earlier studies by Kumar *et. al.*, 2014; Kumar *et. al.*, 2016; Kumar *et. al.*, 2015; Vedna, 2007; Sharma *et. al.*, 2012; Choudhary, 2009a, Choudhary, 2009b.

Technological yield gap

Technological yield gaps affecting yield in lentil was highest (6.7 q ha^{-1}) during 2018-19 while lowest (5.8 7q ha^{-1}) during 2017-18. Generally, the technological yield gaps appear even if the CFLDs' were conducted under the strict supervision of agricultural scientists on the farmers' fields. This may be attributed mainly due to lack of irrigation, poor distribution of rainfall (Sagar and Chandra, 2004), variation in soil fertility, cultivation on marginal lands, non-congenial weather condition, local specific crop management problems faced in order to harness the yield potential of specific crop cultivars under demonstration plots (Chandra, 2004; Vaghasia *et. al.*, 2005; Choudhary *et. al.,* 2009b). These observations indicate that location specific crop management is need of the hour to bridge the gap in potential and demonstration yields (Vedna *et. al.*, 2007).

Figure 1 . Year wise yield performance of lentil

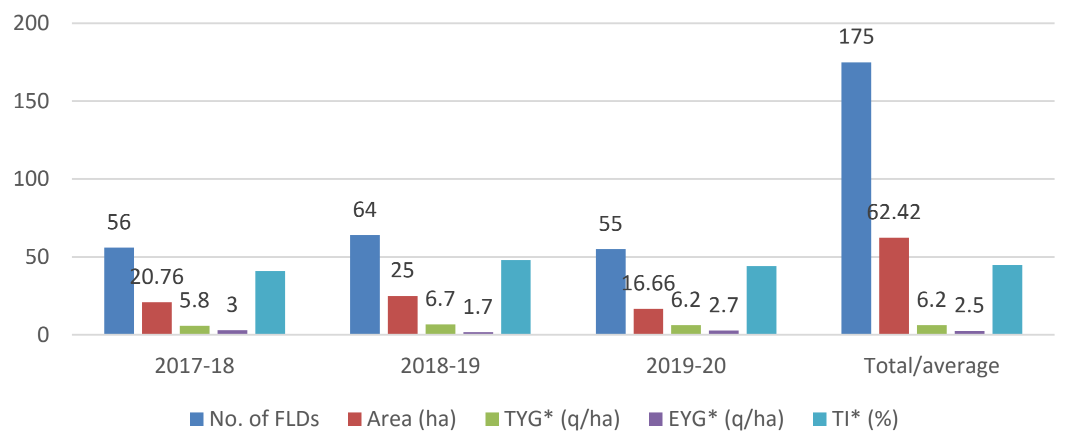

Table 2. Year wise yield performance of lentil

Variety	Years	No. of FLDs	Area (ha)	PY(q/ha)*	ADY* (q/ha)	AYLC* (q/ha)	IOLC* (%)	TYG* (q/ha)	EYG* (q/ha)	TI* (%)
KLS-218	2017-18	56	20.76	14	8.2	5.2	57.69	5.8	3	41
	2018-19	64	25	14	7.3	5.6	30.36	6.7	1.7	48
	2019-20	55	16.66	14	7.8	5.1	52.94	6.2	2.7	44
	Total/average	175	62.42	-	7.8	5.3	47.00	6.2	2.5	45

* PY: Potential Yield, ADY: Average demo yield, AYLC: Average Yield of Local Check, IOLC: Increase Over Local Check, TYG: Technology yield gap, EYG: Extension yield gap, TI: Technology index

Extension yield gap

The successful development, dissemination and adoption of improved technologies for small holders depend on more than careful planning of research the use of appropriate methodologies in extension (Cramb, 2003; Biggs Smith, 1998). The higher extension yield gap indicates that there is a considerable need to educate and convince farmers to embrace improved agricultural technology over existing local practices. Another alternative available to research scientists is to refine local farmers' practices in order to increase adoption of location-specific farm technology in order to maintain crop productivity. Maximum extension yield gap of 3.00 q/ ha was observed during 2017-18 and lowest (1.7 q/ha) during 2018-19 in the present study (Table 2). Extension yield gaps were the indicators of lack of awareness for the adoption of improved farm technologies by the farmers (Kadian *et. al.*, 1997; Vedna *et. al.,* 2007; Choudhary *et. al.*, 2009b).

Technology index

Technology index indicates the feasibility of generated farm technologies in the farmers' fields under existing agro climatic situations (Vedna *et. al.*, 2007; Choudhary *et. al.,* 2009b). Lower the technology index, higher will be the feasibility of generated farm technology under farmers' fields and *vice-versa*. Data in table 2 revealed that technology index varied from 41 per cent to 48 per cent in lentil. Lowest technology index (41.00 %) was recorded during 2017-18 while highest magnitude of technology index (48.00%) was observed during 2018-19. Technology index was quite higher in lentil cultivars in the present study (Table 2), which indicates that there exists a strong gap between the generated technology at the research institution and their further dissemination at the farmers' fields (Kadian *et. al.*, 1997; Vaghasia *et. al.*, 2005; Vedna *et. al.*, 2007; Choudhary *et. al.*, 2009a, Choudhary *et. al.*, 2009b). In Assam, lentil is the predominant *rabi* season pulse, however water stress and poor distribution of winter rains under rainfed farming result in low yields, which could be grounds for reducing crop's cultivation among farmers and contributing to a higher technology index. Poor seed germination and poor stand at early vegetative stage due to water stress under rainfed farming is another possible reason for poor yields causing higher technology index in lentil. As a result, it appears that the rainfed pulses technology package should also incorporate location-specific moisture conservation technologies, allowing these crops to perform better in rainfed situation on farmer's fields.

Economic analysis

In demonstration plots, the highest gross return (51840.00 Rs./ha) and net return (28550.00 Rs./ha) were obtained during 2017-18 while lowest gross (35650.00 Rs./ha) and net- returns (15760.00 Rs./ha) were recorded during 2018-19 (Table 3). The varying performance of lentil in terms of grain yield under improved technology in FLDs may account for the variances in economic returns. Benefit-cost ratio (BCR) of demonstration plots varied between 1.72 to 2.23 with highest BCR during 2017-18 and lowest during 2018-19 owing to variable performance of lentil under demonstration. Enhanced monetary returns as well as BCR through improved farm technology have also been reported by various workers (Chandra, 2004; Vedna, 2007; Choudhary *et. al.,* 2009a, Choudhary *et. al.,* 2009b). Overall, economic analysis data indicated that the transfer of improved technology and its use in lentil might significantly increase farmer profitability, resulting in a better livelihood alternative for farmers in the state who practice rainfed farming.

4. Conclusion

Due to technical and extension gaps, the current study concluded that there is a large gap in potential yields, demonstration yields, varietal yield, and farmers' plot yields under lentil in Assam. The study focuses on disseminating improved crop management technologies imbedded with high yielding varieties (HYVs) to boost lentil production and profitability in rainfed agriculture. This study also suggests that state extension officials should concentrate their efforts on disseminating established lentil production farm technologies in pulse production systems as well as improving irrigation facilities so that resource poor farmers

Table 3. Economic analysis of FLDs and farmers practice for lentil cultivation in Assam

Variety	Years	ACC (Rs./ha)		AGR (Rs./ha)		ANR (Rs./ha)		BC Ratio	
		*DP	*FP	DP	FP	DP	FP	DP	FP
KLS- 218	2017-18	23289	19028	51840	32993	28550	13965	2.23	1.73
	2018-19	20676	15753	35650	23752	15760	8000	1.72	1.51
	2019-20	23384	15964	44917	25813	21533	10724	1.92	1.62

ACC- Average cost of cultivation, AGR- Average Gross Return, ANR- Average Net Return, BC Ratio - Benefit : Cost Ratio, *DP- Demonstration plot FP- Farmers' plot can earn a living on a long-term basis by diversifying their farming systems with pulses in socio-agro-economic situations in Assam. According to the findings, the introduction of high yielding variety (HYV) of lentil embedded with proven location specific farm technology, as well as proper demonstration under CFLDs and an intense awareness campaign, may lead to increased technology adoption in lentil among farmers in the state. Extension workers in Assam should focus solely on disseminating proven farm technology in pulse production systems in order to boost lentil output above current levels. Adoption of agricultural technologies with a focus on efficient utilization and management of necessary inputs is critical for achieving higher agriculture productivity and maximizing economic returns.

5. Acknowledgement

The authors are thankful to the DAC& FW, Ministry of Agriculture and Farmers' Welfare, Govt. of India and heartfelt gratitude to Dr. V.P. Chahal, DDG (Agricultural Extension), ICAR, New Delhi, for his generous support in implementing the CFLD (Pulses) programme and all the colleagues of Agricultural Extension Division in the Council HQ for financial support and their constant encouragement, guidance and support in executing the programme. We sincerely acknowledge the services rendered by the scientist of the KVKs for successful implementation of CFLD on pulse.

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