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Quantifying Yield Gap Minimization in Chickpea under Cluster Front Line Demonstration conducted in Indo Gangetic Plains of Eastern India

MANDHATA SINGH[1]*, V DWIVEDI[2], DEOKARAN[3] AND ARIF PARWEZ[4]

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ABSTRACT

Yield gap of chickpea will be minimized by implementation of suitable location specific agro techniques with timely and careful management. On farm cluster frontline demonstration (CFLD) on chickpea were conducted during *rabi* season of 2015-16 to 2017-18 in Buxar district of Bihar. CFLD was conducted in 20 ha area each with plot size of 0.40 ha (1 acre) with active participation of 50 farmers in two clusters. CFLD was conducted to popularize the demonstrated technology and quantifying the yield gap analysis in chickpea. Demonstrated technology under CFLD enhanced the plant growth and yield attributes. Seed yield of chickpea was recorded higher under CFLD (15.51 q/ha) compared to farmers practice (11.81 q/ha) which was 31.32% higher over farmers practice, 40.81% higher over district yield (11.04 q/ha) and 42.81% higher over state yield (10.86 q/ha). Technology gap was recorded 2.75, 2.50 and 2.20 q/ha in year 2015-16, 16-17 and 17-18, respectively. Extension gap was recorded 3.83, 4.05 and 3.20 q/ha during 2015-16, 16-17 and 17-18, respectively. Technology index was recorded 23.75, 22.50 and 21 % during 2015-16, 16-17 and 17-18, respectively. Average net return of Rs 45700 was recorded in demonstration and Rs 29497 in farmers practice. The net return under demonstration was 54.93 % higher over farmers practice. Average benefit cost ratio of 1.73 recorded with demonstration and 1.15 with farmer's practice.

KEYWORDS
Chickpea, Cluster frontline demonstration, Pulses and Yield gap minimization

INTRODUCTION

Pulses are an important group of food crops that can play a vital role to address national food and nutritional security and also tackle environmental challenges (Singh *et al.*, 2015). The share of pulses to total food grain basket is around 9-10 per cent and is a critical and inexpensive source of plant-based proteins, vitamins and minerals. Pulses are critical in food basket (*dal-roti, dal-chawal*), are a rich source of protein (20-25 %), it is double the protein content of wheat and thrice that of rice) and help address obesity, diabetes malnutrition etc. (Anonymoun, 2018). Pulses play an important role in rainfed as well as partially irrigated agriculture by improving physical, chemical, and biological properties of soil and are considered excellent crops for natural resource management, environmental security, crop diversification and consequently for viable agriculture. Cultivation of pulses builds-up a mechanism to fix atmospheric nitrogen to N-compounds in their root nodules and tend to fix 72 to 350 kg N per ha per year, thereby meeting their own nitrogen requirements to a great extent. In India, pulses are generally produced in poor soils not suited to other crops, with a minimum use of resources and have a very low water footprint. Chickpea or gram (*Cicer arietinum*) is an important pulse crop of the semi-arid tropics, particularly in the rainfed ecology of the Indian sub-continent. Chickpea is rich source of protein, carbohydrates, essential amino acids and vitamins and protein quality is considered to be better than other pulses (Hirdyani, 2014). Chickpea also plays an important role in sustaining soil productivity by improving its physical, chemical and biological properties and trapping atmospheric nitrogen in their root nodules (Singh *et al.*, 2015; Ali and Kumar, 2005).

Chickpea predominantly is the rainfed crop grown in constrained environment. Several causes are responsible for low yield of chickpea of which the use of traditional local cultivars, low plant density per unit area, weed infestation and poor crop management practices constitute the major ones (Merga and Haji, 2019; Singh *et al.*, 2017). The main challenges of research and development are to bridge the gap between actual and attainable yield by enhancing farmers access to quality seed, fertilizers, plant protection measures, improved technologies and information's. Front line demonstrations are one of the practical approaches to maximize the production by display of relevant technologies at farmers' field under strict supervision of agricultural experts helped to narrow down the extension and technological gaps to a considerable extent. "Cluster Frontline Demonstrations (CFLD) on Pulses was started by Ministry of Agriculture & Farmers Welfare, Department of Agriculture and Cooperation, Government of India in 2015-16 under National Food Security Mission with the aim to boost the pulse productivity and nutritional security by educating the farmers with latest and specific technologies. CFLD was implanted by Krishi Vigyan Kendra, Buxar with the main objective to harvesting the yield potential of chickpea and minimizing the district, state and farmers yield gap.

MATERIALS AND METHODS

The present study was the part of cluster frontline demonstrations (CFLDs) on

[1]SMS (Agronomy), KVK, Buxar
[2]Head, KVK, Bhadohi, U.P. (Ex Head) K.V.K., Buxar
[3]SMS (Soil Seience), KVK, Buxar
[4]Technical Officer, KVK, Buxar
(ICAR Research Complex for Eastern Region, Patna), Bihar, India
*Corresponding author email : mandhataagro@gmail.com

Table 1: Comparison between package of CFLD and farmers practice

Particulars	Demonstration	Farmers Practice
Farming situations	Irrigated	Irrigated
Cropping system	Rice-wheat	Rice-wheat
Varity	BGM 547	BG 372
Time of sowing	First fortnight of November	Hole November to 10 December
Field preparation/Tillage	Minimum tillage	Conventional tillage
Method of sowing	Line sowing	Broadcasting
Seed rate	80 kg/ha	80 kg/ha
Seed treatment	*Trichoderma harzianum*, *Rhizobium* culture	No seed treatment
Fertilizer dose and application	N:20 P:50:K:30, spray of 2% Urea at 35 DAS	N:18 P:46 (use only 100 kg DAP/ha)
Micronutrient application	Application of B and Mo at 50 DAS/before flowering	No use
Weed management	Pre emergence application of pendimethalin+1 HW	No use of herbicides, one hand weeding at 45 DAS
Plant Protection	Spray of Neem oil and Pheromone trap for controlling gram pod borer	Use insecticides (*Emamectin benzoate*) for controlling gram pod borer

pulses being implemented by Indian Council of Agricultural Research (ICAR), New Delhi, India across the country. Cluster frontline demonstration (CFLD) on chickpea were conducted during *rabi* season of 2015-16 to 2017-18 in Buxar district in 20 ha area each with plot size of 0.40 ha (1.0 acre) were included under these demonstrations with active participation of 50 farmers in two clusters. Before conducting the CFLD farmers were selected and one training on scientific cultivation and management of chickpea was conducted. Soil samples of all the sites were collected and analyzed for nutrient management.

Under CFLD all the package of practices were used with seed treatment with fungicides, insecticides and *rhizobium*, minimum tillage, line sowing, spray of neem oil (1500 ppm) 3 ml/lit of water for controlling the pod borer and one foliar spray of boron + molybdenum 2 ml/lit of water before flowering in demonstration plots. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale (Table 1). The demonstration farmers were facilitated by KVK scientists in performing field operations like sowing, fertilizer application, pest management, weed management, harvesting etc. (Fig. 1). The necessary steps for selection of site and farmers, layout of demonstration etc. were followed as suggested by Choudhary (1999).

The traditional practices were maintained in case of local checks. Demonstration was conducted to quantifying the yield gap analysis in chickpea. Number of branches and nodule count were collected from each demonstration plot and farmers plot. Yield attributing parameters were collected from each demonstration and farmers plot. For calculation of crop yield crop cutting were conducted in the presence of large number of farmers for popularization of demonstrated technology. Protein content was worked out by multiplying the percentage value of nitrogen content of seed with the factor 6.25. Economic analysis was done on the basis of prevailing market price of input used and output obtained from treatments (Table 2).

The estimation of technology gap, extension gap and technology index and yield gap minimized were estimated using following formula (Dwivedi *et al.*, 2014):

Fig.1: Chickpea under Cluster Front Line Demonstration at farmers field.

Table 2: Cost of cultivation of CFLD and farmers practice

Input	Demonstration Cost (INR)	Farmers Practice Cost (INR)
Field preparation	2400	3200
Seed	6400	6400
Seed treatment	600	0
Sowing	1000	1000
Nutrient management	4400	2600
Weed management	4700	6000
Plant protection	1500	1367
Harvesting & Threshing	6100	5000
Total	27100	25567

i) Percent yield increase = $\frac{\text{Demonstration yield-Farmers yield}}{\text{Farmers yield}}$

ii) Technology gap = Potential yield-Demonstration plot average yield

iii) Extension gap = Demonstration plot average yield - Farmer's plot average yield

iv) Technology Index = $\frac{\text{Pi- Di}}{\text{Pi}} \times 100$

Where, Pi = Potential yield of i crop

Di =Average demonstration plot yield of i crop

RESULTS AND DISCUSSION

Crop growth, yield attributes and quality

Data related to chickpea growth viz. number of branches, number of nodules per plant and yield attributes viz. number of pods/plant, 100 seed weight influenced by demonstration (Table 3). Number of branches per plant (21) was recorded maximum under demonstration over farmer's practice (17). Number of nodules per plant (26.42) in demonstration was recorded 42.04 % higher over farmer's practice (18.60). Number of pods/plant was recorded higher in demonstration and it was 30.89 % higher over farmers practice. 100 seed weight was also recorded maximum under demonstration plot (23.8 g) compared to farmers practice (22.7). This was mainly due to proper follow of package of practices in demonstration plot, seed treatment with rhizobium culture, PSB and *Trichoderma* enhanced the nodulation and protect the plant to different soil borne diseases (Mishra *et al*., 2012 and Singh *et al*., 2014). Protein content (21.3%) was recorded higher in demonstration compared to farmers practice (20.8%). This was mainly due to farmers using indigenous and very old variety and CFLD new variety used. Protein yield (330.36 kg) was also recorded maximum in demonstration plots compared to farmers practice (245.64 kg/ha). This might be due to adoption of good agronomic practices and suitable cultivar enhanced the seed yield of chickpea and good protein content (Singh *et al*., 2017).

Data on seed yield of chickpea showed demonstration plot yield was increased over the year and demonstrated technologies also have significant impact on district yield as well as state yield (Table 4). Farmers plot yield was also improved over the year. Average yield of demonstration plot was recorded 31.32% higher over farmers plot yield (11.81 q/ha), 40.48% higher over district yield (11.04 q/ha) and 42.81% higher over state yield (10.86 q/ha). Demonstration of technologies in CFLD showed significant impact and farmers learn about the scientific agro-techniques and their timely application and management. Per cent yield increase over farmers field was varies from 25.39 to 35.72 %. Initial years of demonstration yield increases of chickpea were recorded 33.53%, in second year of demonstration it was 35.72% higher over farmers practice and in third year it was 25.39 % (Table 4). District yield gap of 10.79, 8.01 and 8.07 q/ha was recorded in 2015-16, 16-17 and 17-18, respectively. State yield gap was recorded 10.14, 8.80 and 8.46 q/ha in 2015-16, 16-17 and 17-18, respectively. Farmers yield gap was recorded 8.58, 8.58 and 7.40 q/ha in 2015-16, 2016-17 and 2017-18, respectively. The difference in yield gap with respect to potential yield was reduced over the year in district, state and farmers yield. This might be due to popularization of improved agro-techniques at farmers field and supply of quality seed and other input to the farmers and farmers multiplied the seed over the year and reaches to other farmers of the district (Dubey *et al*., 2018).

Technology gap

Technology gap was recorded maximum in initial year of demonstration and it was decreasing over the years. Technology gap was recorded 2.75, 2.50 and 2.20 q/ha in year 2015-16, 16-17 and 17-18, respectively (Table 5). This may be attributed to lack of good quality of seed, bio fertilizers, irrigation facility, crop establishment methods, herbicides for weed control and plant protection measures and location specific crop management problems (Saikia *et al*., 2018). The location specific crop management is required to bridge the gap in the potential and demonstration yield.

Extension gap

Extension gap are the indicator of lack of awareness for the adaptation of improved farm technologies by the farmers. The successful development, dissemination and adaptation of improved technologies for small and marginal land holder

Table 3: Effect of CFLD and farmers practices on growth, yield attributes and protein yield of chickpea

Treatments	No of branches/plant	No of nodules/plant	No of pods/plant	100 seed weight (g)	Protein content (%)	Protein yield (kg/ha)
CFLD	21	26.42	88.25	23.8	21.3	330.36
Farmers practice	17	18.60	67.42	22.7	20.8	245.64

*Cluster Frontline Demonstration

depends on more than careful planning of research and use of appropriate methodology (Choudhary *et al.*, 2013). Extension gap was recorded 3.83, 4.05 and 3.20 q/ha during 2015-16, 16-17 and 2017-18, respectively (Table 5). First year of demonstration extension gap was 3.83 q/ha and in 2017-18 it was decreased and recorded 3.20 q/ha. This showed that proper monitoring and popularization of technology amongst the farmers reduced the extension gap (Saikia *et al.*, 2018).The higher extension gap indicates that there is strong need to more aware and motivate the farmers which is emphasizing on need to educate farmers through various means of adaptation of improved agricultural production technologies over existing local practices to minimize the extension gap.

Technology index

Technology index indicates the feasibilities of the evolved technology in the farmer's field under existing variations. Lower the value of technologies index, higher the feasibility of the improved technology. Technology index was recorded 23.75, 22.50 and 21% during 2015-16, 16-17 and 17-18, respectively (Table 5). This was mainly due continuous demonstration at farmer's field and organized training, field day and other awareness programmes motivated to the farmers to adopt new agricultural production techniques for harnessing the potential yield of crop (Saikia *et al.*, 2018).

Economics

Economic analysis highlights that use of improved technology and its adoption has substantially enhanced the farm gains over farmer's practice which indicated that use of farm technology can greatly improve the livelihood and profitability of the farming community. Economic analysis of data indicated that cost of cultivation under farmers practice was lower compared to demonstration (Table 5). The higher cost of cultivation under demonstration was mainly due to adoption of seed treatment package, balanced nutrient management and higher harvesting and threshing cost because of higher yield in demonstration. Net return of demonstration plot was recorded higher to farmers practice in each years of demonstration. Average net return of Rs 45700 was recorded in demonstration and Rs 29497 in farmers practice. The net return under demonstration was 54.93 % higher over farmers practice. Average benefit cost ratio of 1.73 recorded with demonstration and 1.15 with farmer's practice, which showed that technology under demonstration was supportive to farmers and economically viable (Khedkar *et al*. 2017; Singh 2016).

Table 4: Yield advantage accrued due to CFLD

Year	Area (ha)	No of farmers	Yield (q/ha)					% increase over farmers yield	Absolute yield gap (q/ha) w.r.t. potential yield		
			District	State	Potential	CFLDs	Farmers practice		DYA	SYA	FYA
2015-16	20	50	9.21	9.86	18	15.25	11.42	33.53	8.79	8.14	6.58
2016-17	20	50	11.99	11.20	18	15.50	11.45	35.72	6.01	6.80	6.55
2017-18	20	50	11.93	11.54	18	15.80	12.6	25.39	6.07	6.46	4.40
Average	20	50	11.04	10.86	18	15.51	11.81	31.32	6.95	7.13	5.54

Table 5: Technology gap, extension gap, technology index and economics of CFLDs and farmers practice

Year	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)	Farmers Practice				CFLDs			
				Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
2015-16	2.75	3.83	15.27	24500	57100	32600	1.33	25300	76250	52250	2.17
2016-17	2.50	4.05	13.88	26100	51525	25425	0.97	28000	69750	41750	1.49
2017-18	2.20	3.20	12.22	26100	56700	30600	1.17	28000	71100	43100	1.53
Average	2.48	3.69	13.85	25567	55063	29497	1.15	27100	72367	45700	1.73

Sale price of Chickpea Rs 5000/q in 2015-16, Rs 4500/q in 201617 and 2017-18

CONCLUSION

On the basis of three years of cluster front line demonstration seed yield of chickpea pea was recorded 31.32% higher over farmers practice. Net return and benefit cost ratio was also higher under demonstration over farmers practice. Potential yield of chickpea can be achieved by imparting scientific knowledge to the farmers, providing the quality seed and need based other inputs and proper application techniques of inputs. Horizontal spread of improved technologies might be achieved by the successful implementation of frontline demonstrations and various extensions activities.

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