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Assessment of Technology and Yield Gap of Chickpea in Bundelkhand Region of Uttar Pradesh, India

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Authors' contributions

The work was carried out by the contribution of all the authors. Author MPS conducted the demonstrations at farmers field. Authors MC and BPM designed the demonstration, supervised and provided necessary support to team for smooth execution of demonstrations. Authors BKG and AM wrote the manuscript. Author Gaurav supported in data collection. Author SK statistically analyzed the data and supported in editing of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Bundelkhand region of Uttar Pradesh (UP), India is a major pulse producer in the Indian subcontinent. The agriculture production, particularly, pulses have been playing a great role in strengthening the economic conditions and are the source of livelihood of Bundelkhand region of Uttar Pradesh state. The productivity of chickpea crop is low due to lack of adoption of best management practices of chickpea by farmers. Keeping these constraints under consideration the yield gap and technology gap assessed of the region by conducting Cluster Front Line Demonstrations on best management practices of chickpea during *Rabi* seasons in the year 2015-16 to 2018-2019, respectively. The demonstration was carried out in six villages of Mahoba district.

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The results revealed that the full technological gap in 5 practices (variety, seed treatment, seed inculcation with Rhizobium, weed management practices and plant protection), a partial gap in 3 practices (seed rate, fertilizer management and irrigation) and Nil gap in 2 practices (land preparation and sowing methods). Further, Average grain yield of chickpea showed a remarkable increase (32%) in CFLDs compared to Farmers practice (check). However, it is still behind to potential yield. The average technological gap, extension gap and technology index were 8.10 q ha^{-1} , 3.30 q ha^{-1} and 36.6% respectively. The study recommends the improvement of productivity of chickpea may be achieved through fulfilling the gap between demonstration yield and farmers practice yield. Therefore, more effort requires to determine the socio-economic factors for practicing age-old practice and extension efforts needed to the rapid diffusion of best management practices. Further, The future study on variable climate conditions and edaphic factors requires to determine the gap between potential and demonstration yield.

Keywords: Chickpea; best management practices; cluster front line demonstration.

1. INTRODUCTION

Chickpea (gram) is an important pulse crop in India. India is a major producer and consumer of pulse in the world. India has the first rank in pulse production (25.23 million tons) and area (29.99 million ha) in which chickpea recorded a production of 111.58 lakh tons and an area of 105.73 lakh ha, the productivity 1053 kg ha^{-1} during 2017-18 [1]. The Uttar Pradesh has 6.11 lakh ha area and production 6.84 lakh tones. Nutritional security is paramount issue in country, as most of the Indian population is vegetarian and pulses are the main source of protein. As per the WHO recommendation pulse consumption in India should be $80 \text{ g capita}^{-1} \text{ day}^{-1}$. However, it per capita availability is only 42 g day^{-1} [2]. Therefore, pulse production has to increase with the escalating population of the country. Chickpea is the major contributor in total pulse export in India. Bundelkhand region of Uttar Pradesh is a major pulse growing area of India. The livelihood of farm households in the region is fully dependent on agriculture. The chickpea is grown on 0.38 lakh ha in the region with the productivity of 13.1 kg ha^{-1} . The traditional methods of cultivation like use of poor quality seed, no use of external inputs (fertilizer, weedicide and pesticide), sowing of crop with broadcast method could be major constraint of low productivity. The several researchers reported that improved pulse production cultivation practices [3] and [4] such as high yield varieties, seed treatment, line sowing, integrated pest and weed management have potential to improve productivity of chickpea. These best management practices (BMPs) have the potential to improve the pulse production in the region. The cluster front line demonstration (CFLD) is proven extension approach for the creation of awareness and dissemination of the

technologies. In CFLDs, farmers and scientists work closely and exchange their ideas [5]. The CFLDs were conducted under National Food Security Mission for promotion of pulse. However, to the potential yield of cultivars are generally higher than actual yield. Potential yield of cultivars grown in which it adopted and other inputs are non-limiting [6], however, it is very difficult to achieve potential yield as biotic factors are most limiting. However, the maximum achievable yield can be defined as economic produce of crop under the best management practices, while the actual yield can be defined as economic produce by the farmers under their limited resources. To minimize the difference between different types of yield. It is necessary to determine the yield gap and technological gap responsible for the poor yield. Keeping these constraints under consideration, a study was conducted to improve the productivity of the chickpea by determining the technological gap, extension gap and technology index.

2. METHODOLOGY

A study was conducted at Mahoba district (Fig. 1), six villages of districts selected purposely in which chickpea is a dominated crop. The cluster front line demonstration (CFLD) was carried out in six villages namely Koniya, Lamoura, Atarpatha, Jaitpur, Bharwara and Amanpura of Mahoba district to assess the technology and yield gap between CFLDs and farmers practices (check). The climate of Mahoba is dry sub-humid. The soil is clay loam with normal pH of 7.2 and EC of 0.27 dSm^{-1} , organic carbon 6.7 g/kg soil. The nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) were 285, 36 and 219 kg/ha , respectively. At experimental site, total rainfall was 843.4, 498,687, and 556 mm during cropping season of 2016 and 2019, respectively.

In which 80 to 90 % rainfall received during July to September months and only 10 to 15 % rainfall during Rabi Season. Total of 115 CFLDs was conducted during *Rabi* season in four consecutive years (2015-16 - 2018-19). The ten best management practices (BMP) were selected comprised improved high yielding and location-specific varieties (KWR-108, JG-14 and RVG 202), optimum seed rate (80 kg ha⁻¹), line sowing, seed treatment, applied balance dose of fertilizers on the soil test basis, timely weed management, irrigation scheduling and plant protection measures. The BMP was based upon a number of the year proven research and recommendation of crop management practices at the time of variety release. The CFLDs were conducted on farmers' field and monitored by experts. The same number of nearby farmers was selected for the collection of actual

information of chickpea crop grown under the management of farmers. The crop yield was determined from each plot of CFLDs and farmers practice by crop cut taken from 25 sqm at 3 spots of an individual field. Yield expressed in q ha⁻¹. The economic analysis of both CFLDs and farmer practice comprised both fixed (land revenue and depreciation cost of farm implements) and variable cost includes human labour, irrigation and all the inputs used during crop cultivation. The expenditure incurred in different activities during cultivation had collected from the CFLDs and Farmer practices for determination of cost of cultivation, net return and benefit-cost ratio.

The technology gap, extension gap and technology index were calculated by adopting the following equations given by [7].

$$\text{Technology gap} = \text{Potential yield} - \text{Demonstration yield} \quad (1)$$

$$\text{Yield gap} = \text{Demonstration yield} - \text{Farmers yield} \quad (2)$$

$$\text{Technology Index} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100 \quad (3)$$

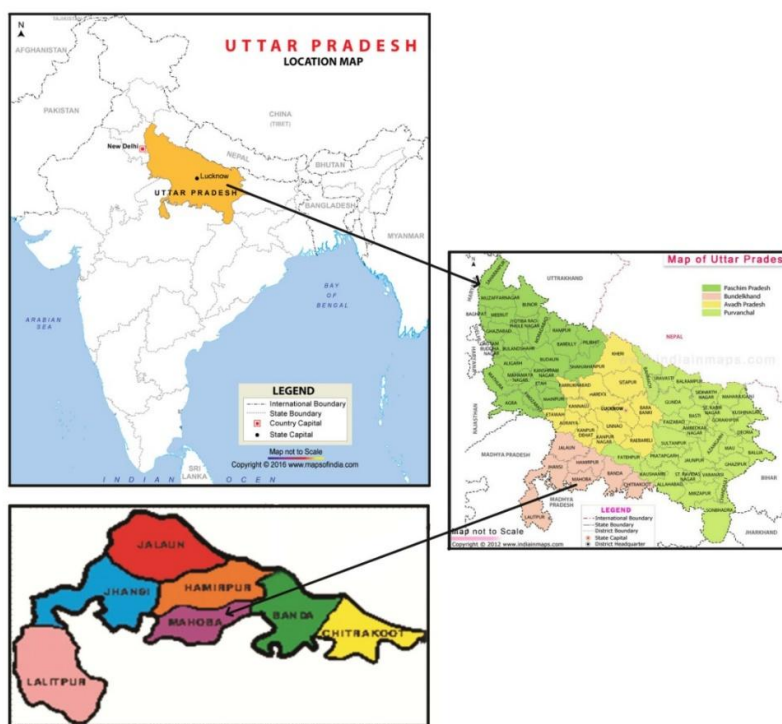


Fig. 1. Map of the Mahoba district, Bundelkhand region of Uttar Pradesh India

3. RESULTS AND DISCUSSION

The adoption gap was worked out by the following the standard procedure of 3 gaps, i.e. full gap (Not adopted best management practices), partial gap (Not fully adopted best management practices) and Nil (fully adopted best management practices) (Table 1). Among the selected 10 best management practices, five practices had not adopted by the farmers viz. varieties, seed treatment, seed inoculation, weed management and plant protection. Not adoption of these practices could be the cause for low productivities of chickpea in the region. Selection of improved high yield variety is striving for obtaining a better yield [8]. The partial gap was found in 3 best management practices viz. seed rate, fertilizer management and irrigation. Chickpea crop requires less irrigation thereby only one irrigation (30 mm) is recommended for the sowing of crop. Whereas, nil gap was observed in two practices land preparation and sowing methods [8]. Overall, it indicates that more extension efforts are needed to disseminate best management practices to the farmers for ensuring the adoption of all the practices.

3.1 Seed Yield of Chickpea

Data depicted on Table 2, an average of 4 years and 115 demonstrations sites revealed that seed yield of CFLDs (13.6 q ha^{-1}) was higher than farmer's practices (10.4 qha^{-1}), CFLDs increased 30.77 per cent seed yield as compared to farmer's practices. Therefore, the region has a huge opportunity for improvement in crop productivity of chickpea. Dissemination of BMP could be a better option. However, the yield obtained in CFLDs plots was still lower than the potential yield. It may be due to the harsh climatic condition of the region, almost negligible rain during the dry season and higher temperature at the time of maturity of the crop led to lower yield of CFLDs [9,10,11].

3.2 Technology Gap

In case of the technology gap, the differences between potential yield and yield of demonstration plots were 10.88, 7.2, 12.3 and 2.16 q ha^{-1} during *Rabi* 2015-16 to 2018-19 respectively. On an average technology gap under four years CFLDs programme 8.10 q ha^{-1} . It exhibits scope of further improvement in CFLDs yield by refinement of best management practices in consideration with agro- climatic conditions and soil factors. The technology gap

observed may be due to dissimilarity in fertility status, climatic conditions etc. It may be taken as the location-specific refinement in BMPs is required to fulfill the technological gap. (Table 2)

3.3 Extension Gap

Extension gap of 2.08, 2.80, 3.20 and 4.94 q ha^{-1} was observed during *Rabi* 2015-16 to 2018-19 with on an average 3.30 q ha^{-1} . It is needed to educate the farmers through various extension activities for the adoption of improved technology. Poor linkage between farmers and extension agencies may be one of the important factors responsible for the low adoption of best management practices (Table 2). It is therefore need to educate the farmers on improved crop management practices to decrease the extension gap, which is possible through more extension efforts [12].

3.4 Technology Index

A perusal of information given in Table 2 revealed that the technology index ranged from 10.80 to 53.48 percent in 2018-19 and 2016-17, respective. It indicates, the climatic factors govern the technology index, favorable climatic condition during 2018-19 reduces index and harsh climatic condition adversely affected the performance of the demonstration. Overall four-year average of technology index was 36.6 per cent. It may be taken as requirement of location-specific research on BMPs, which have ability to perform variable climatic conditions [13].

3.5 Economics of Demonstration

The economic viability of improved technologies over traditional farmer's practices was calculated depending on prevailing prices of inputs and output costs. It was found that the cost of production varied from Rs.16900 to 24500 /ha with an average Rs.20025 /ha of improved technology against the variation in the cost of production Rs 14750 to 19500 /ha with an average of Rs. 17637.5 /ha in local check. Cultivation of improved technologies gave higher net return ranges from Rs. 21186 to 54004 ha^{-1} with a mean of Rs. 35125 ha^{-1} . The improved technology also gave higher benefit-cost ratio 2.25, 3.01, 2.43 and 3.20 compared to 2.09, 2.65, 1.84 and 2.78 under local check in the corresponding season. The higher net return and benefit cost ratio might be due to the better production of chickpea crops grown under CFLDs compared to farmers practice [9] (Table 3).

Table 1. Adoption gap in best management practice and farmers practices of chickpea

S.N.	Technology	Improved practices	Farmers practices	Gap
1.	Varieties	KWR-108, JG-14 and RVG 202	<i>Chani</i> (ND)	Full gap
2.	Land preparation	Ploughing & Harrowing	Ploughing & Harrowing	Nil
3.	Sowing method	Line sowing by Seed drill	Line sowing by Seed drill	Nil
4.	Seed rate	80-90 kg/ha	100-120 kg/ha	Partial (High seed rate)
5.	Seed treatment	With Carboxin 37.5% + Thiram 37.5% @ 2 g kg ⁻¹ of seed	No Seed treatment	Full gap
6.	Seed inoculation	Rhizobium & PSB	No seed inoculation	Full gap
7.	Fertilizers management	18 kg N + 46 kg P ₂ O ₅ /ha	Only 25 kg DAP	Partial
8.	Pre-emergent weedicide application	Apply Pendimethalin @ 3.3 litre/ha.	—	Full gap
9.	Irrigation	Two irrigations at pre flowering and pod development stage	One irrigation	Partial
10.	Plant protection	IPM	Non judicious use	Full gap

Table 2. Yield and gap analysis of cluster front line demonstrations on chickpea

Year	No of Demo	Area (ha.)	Variety	Yield (q ha ⁻¹)		% increase	Potential yield (q ha ⁻¹)	Technology gap (q ha ⁻¹)	Extension gap (q ha ⁻¹)	Technology Index (%)
				Demo	Check					
2015-16	23	6.30	KWR-108	11.12	9.04	23.00	22.0	10.88	2.08	49.45
2016-17	17	3.70	KWR-108	14.80	12.0	23.73	22.0	7.20	2.80	32.73
2017-18	25	10	JG-14	10.70	7.50	42.67	23.0	12.30	3.20	53.48
2018-19	50	20	RVG-202	17.84	12.90	38.20	20.0	2.16	4.94	10.80
Average	115	40	-	13.6	10.4	30.77	21.8	8.10	3.30	36.60

Table 3. Economic analysis of cluster front line demonstrations on chickpea

Year	Cost of cultivation (Indian Rupee)		Net Return (Indian Rupee)		BCR	
	Demo	Check	Demo	Check	Demo	Check
2015-16	16900	14750	21186	16212	2.25	2.09
2016-17	17200	15800	34600	26200	3.01	2.65
2017-18	21500	20500	30710	17466	2.43	1.84
2018-19	24500	19500	54004	34696	3.20	2.78
Average	20025	17638	35125	23644	2.7	2.3

4. CONCLUSION

The results of 4 years' study revealed that technological and yield gap, it was 8.10 q ha⁻¹ regarding technological gap and 3.10 q/ha yield gap. The technological gap may not be completely fulfilled in the region due to low rainfall during crop growing season, scarcity of irrigation water and resource-poor farmers. However, there is a huge opportunity to improve the chickpea productivity by fulfilling the yield gap. Cluster front line demonstrations on BMP have the potential to bridge the gap by sensitization and creation of awareness among the farmers of the region. Further, study strongly recommends future research and extension work for the determination of the socio-economic reason for practicing age-old practice by the farmers and rapid diffusion of BMP.

CONSENT

As per international standard farmers written consent has been collected and preserved by the author(s) for conducting the demonstration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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