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Research Paper

Impact of frontline demonstration on yield and economics of chickpea (*Cicer arietinum* L.) under rice-fallow condition of West Bengal

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ABSTRACT

Front Line Demonstrations (FLDs) are an innovative way to establish a direct channel of communication between researchers and farmers as the scientists are actively involved in the design, execution, and observation of the program. A front-line demonstration program was initiated in different villages of three districts of West Bengal during the years 2019-20, 2020-21 and 2021-22 at 112 farmers' fields under 40 ha area. A parallel experiment of improved technology and farmer-practiced technology and its clear comparison were set up in each demonstration location. Results of the study revealed a clear increment in yield with improved technology practices over the locally practiced technology. The average yield of the chickpea plots with farmers practiced technology was 1060 kg/ha while it was increased by 24.21%, yielding 1316 kg/ha in the improved technology demonstration plots. Even though the average cost of cultivation increased slightly (INR. 36,000/ha), improved technology practices resulted in higher average gross return (INR. 66,627/ha), net return (INR. 30,627/ha) and B:C ratio (1.85).

***Key words:** Chickpea yield, Extension gap, Front-line demonstration, Improved technology, Local practice, Rice fallow, Technology gap, Varieties*

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a major winter-grown food legume crop in India. Chickpea or Garbanzo bean is popularly known as Chana, Brown gram, Bengal gram and Kabuli gram in India. It is used for different food purposes i.e., consumed as leafy vegetable, chana dal, flour (Besan), as well as fodder. A variety of snacks, sweets, and dishes can be made from chickpea flour. As a food, it aids in weight management, improves digestion, and is also a good option for diabetes patients due to having a low glycemic index (Wallace *et al.* 2016). Seeds of chickpeas contain around 20-22% protein and 60% carbohydrate (Jukanti *et al.* 2012). The desi type of chickpea contributes to around 80% while the kabuli type contributes around 20% of the world's chickpea production (Verma *et al.* 2021). With 71% of the global chickpea production area and a contribution of almost 70% to the global production, India is the world's largest producer of chickpea (Sharma *et al.* 2020). India produced 13.75 mt of chickpeas in 2022 (E & S Division, DA & FW). Chickpea production also fluctuates from year to year because of adverse weather conditions during the winter season and recorded a sharp decline over the years (Pandey *et al.* 2012). Chickpea is a suitable winter pulse crop for farmers to grow on residual soil moisture, i.e., without irrigation, following the harvest of transplanted main season kharif paddy in medium to low land situations and also the crop can be given irrigation where facilities are available.

The frontline demonstration program was primarily introduced by the Indian Council of Agricultural Research (ICAR) with a motive to relay the technical knowledge from the scientists to the farmers to improve their skills in using proper inputs more efficiently in the field and achieve good crop management and ultimately gain a higher crop yield. About 11.6 million hectares of rainfed rice land remains fallow in the post-rainy season (Jha *et al.* 2018). This land can be used for less water requiring a second crop like chickpea. Different multidimensional techniques are available for securing a higher yield of chickpea under rice fallow conditions. Before sowing chickpea, crop soil moisture must be checked to ensure proper germination. The rice crop field should be well leveled for maintaining uniform soil moisture which facilitates uniform seed germination of the latter crop. The planting geometry of rice crops also plays an important role in the production of succeeding 'paira' chickpea crop. Machine transplanted or line transplanted rice crop gives higher yield itself rather it also helps the second crop gain a higher yield. During sowing of chickpea, it facilitates germination, proper establishment, and minimal disturbance of chickpea crops during harvesting of rice crops (Mahmood *et al.* 2003). In relay cropping system, land is not prepared and seeds are sown in wet soil. Low to medium lands, characterized by clay loam soil with high water holding capacity are suitable for growing chickpea crops after rice. Often the residual soil moisture is sufficient for chickpea plant growth and development (Hedayetullah and Sadhukhan 2018).

In rice fallow situations, cultivating chickpeas proves to be a low-cost feasible option that can be grown without irrigation using only residual soil moisture and can escape terminal drought (Jha *et al.* 2018). A good combination of agronomic packages and practices have been developed for these conditions, but the principal constraint remained the difficulty in establishing a reasonable crop stand once the surface layers of the soil had dried out. Sowing well-soaked chickpea seeds is important for ensuring a good crop stand. The seed-priming technology gives better results compared to non-primed seeds (Hedayetullah *et al.* 2017). There is ample scope for chickpea as a second crop with a full package of practices in new alluvial regions, as it prefers moderate soil moisture for their growth and development which is available in this region.

MATERIALS AND METHODS

The experiment was conducted at the farmer's field of Bankura, Birbhum, and Murshidabad districts of West Bengal for three consecutive years from 2019-20 to 2021-22. The demonstration was initiated in different villages of these three districts on a total of 40-hectare areas. Each demonstration was conducted with full support of improved packages. Under the full package, seed, fertilizer, and seed inoculations were provided.

A total of 112 farmers were selected from different villages for the demonstration of chickpea which is a predominantly cultivated crop in that area. The history of the farmers was updated i.e., crop history (rice-rice-rice; rice-boro rice; and rice-vegetables etc.). Before the commencement of the demonstration program, farmers were made aware of the latest package of practices of chickpeas. Also, less water, less inputs, and less labour-requiring crop production technologies which were developed for chickpeas were demonstrated to the farmers in the field. A parallel experiment of improved and farmer practiced, and its clear comparison was set up.

Table 1. Number of farmers from different districts across the years.

Year	District	Farmer (No.)
2019-20	Murshidabad	12
	Birbhum	6
	Nadia	2
2020-21	Murshidabad	22
	Birbhum	5
	Hooghly	5
	Bankura	8
2021-22	Bankura	38
	Birbhum	3
	Murshidabad	11
Total		**112**

The farmers were selected in such a way that they comply with some criteria, i.e. a) all demonstrations should be laid in a 1.0 ha area and should be in a cluster in the same village, b) one demonstration at individual farmer should never be less than 0.4 hectare and not exceeding one hectare, c) other equal size plots of the demonstrating farmers or the equal size of the plot of neighboring farmers in the same farming situation may be considered as check plot or control plots with an objective for comparison of the results, d) the farmer should have the field vacant or available at the required sowing dates. These selected farmers received targeted skill training, encompassing guidance on modern agro-techniques for crop production and plant protection management to enhance cultivation practices.

'Pusa 3043', 'GNG 2207' and 'GNG 2299' were used as improved varieties which were compared with local varieties such as 'Anuradha', 'Mahamaya 1' and 'Mahamaya 2' which are old varieties of chickpea having less yield potential. There is an urgent need for seed replacement to secure higher yields as well as farmer's income. Other components of the improved package of practices were proper land preparation, line sowing (30 cm × 10 cm), seed treatment with *Rhizobium* and *Trichoderma* inoculation, using imbibed seed for sowing, balanced fertilizer application and using PSB culture to mobilize phosphorus in soil.

The technology gap, extension gap, and technological index (%) along with surplus cost, surplus return, and surplus gains were calculated by following the procedures suggested by Samui *et al.* (2000) and Kumar (2014).

Technology gap = Potential yield- Demonstration yield

Extension gap = Demonstration yield-Farmers' practice yield

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

Surplus cost (Rs/ha) = Demonstration cost – cost under Farmers' practice

Surplus returns (Rs/ha) = Return under demonstration – Return under farmers' practice

Surplus gains (Rs/ha) = Surplus return – Surplus cost

RESULTS AND DISCUSSIONS

Improved technology v/s farmer's practice

Some major and a few minor differences were noticed between the demonstrated improved technology and the farmer's practiced technology of chickpea cultivation during the three-year-long demonstration program. The differences are presented in Table 1 for a clear comparison and proper understanding of the methods/inputs where more improvements may be needed on the farmers' side. Various technological components were critically analyzed among which, a full gap was noticed in some particulars such as variety, soil testing, seed treatment, seed inoculation, sowing method, and irrigation while, partial gaps were observed in land preparation, seed rate, and fertilizer dose. Similar findings have also been reported by Jyothi and Lahari (2022). Farmers were using age-old varieties which had a low potential yield and were susceptible to disease and pests probably due to their unawareness of modern high-yielding disease and pest-resistant varieties. Due to the lack of available agro-technologies, no soil testing had been done by the farmers and imbalanced fertilizer application was also noticed. Furthermore, farmers usually sow chickpea by broadcasting the seeds with a high seed rate which is not recommended because of uneven germination and irregular plant population. Similar findings have also been reported by Singh *et al.* (2020).

Grain yield

The results obtained from the front-line demonstration program are presented in Table 2. The presented data reveals that the mean yield achieved using improved technology was 1316 kg/ha, compared to 1060 kg/ha in farmer's practice plots, reflecting a significant yield increase of 256 kg/ha or approximately 24.15%. The highest yield obtained in the FLD plots was 1378 kg/ha during the year 2019-20 while the highest yield obtained in the farmer's practiced plots was 1104 kg/ha during the year 2020-21. The lowest yield obtained in the FLD plots was 12.17 kg/ha during the year 2021-22 while the lowest yield obtained in the farmer's practiced plots was 987 kg/ha during the year 2021-22. The highest yield of 1378 kg/ha was achieved with variety with 'Pusa 3043'.

The increase in yield in the FLD plots over the farmer's practiced plots varied between 22.69% to 26.68% with an average increase of 24.21% over the farmer's practice. This data clearly shows the effect of improved production technology over farmer's practices in enhancing grain yield. The improved chickpea grain yield could be attributed to the use

Table 2. Difference between demonstrated improved technology and farmer's practiced technology

Particulars	Improved technology	Farmer's practice	Gap
Variety	Pusa 3043, GNG 2207, GNG 2299	Anuradha, Mahamaya-1, Mahamaya-2	Full
Soil testing	Proper soil testing is done	Usually not followed	Full
Land preparation	2 ploughing, 1 harrowing	Only 1 ploughing	Partial
Seed rate	60 kg/ha	80-100 kg/ha	Partial
Seed treatment	Carbendazim @ 2 g/kg seed or, *Trichoderma viride* @ 5 g/kg seed	No seed treatment	Full
Seed inoculation	*Rhizobium* and PSB culture @ 20 g/kg seed	No seed inoculation	Full
Sowing method	Line sowing	Broadcasting	Full
Sowing time	Last week of October to 1st fortnight of November	Last week of October to 1st fortnight of November	Nil
Fertilizer dose	20:40:40 kg/ha NPK	Imbalanced	Partial
Irrigation	One at pre flowering, one at pod formation	No irrigation given	Full
Weed management	Pre emergence application of Oxyfluorfen 150 g a.i./ha, followed by one hand weeding at 30 DAS	Only one hand weeding	Partial
Plant protection	Emamectin benzoate (5 SG) @ 0.5 g/ to control gram pod borer (*Helicoverpa armigera*)	Use mix of insecticides or whichever locally available	Partial

of modern high-yielding varieties and improved agro-technologies such as seed treatment, seed inoculation, line sowing, balanced fertilization etc. Similar results of yield increment were also reported by Bharti *et al.* (2024), Kumari *et al.* (2023) and Rajpoot (2020).

Technology gap

The technology gap is the difference between the potential yield and the demonstration plot yield which was 322 kg/ha, 346 kg/ha and 283 kg/ha for varieties 'Pusa 3043', 'GNG 2207' and 'GNG 2299' respectively. On average, a technology gap of 317 kg/ha was noticed during the FLD program. Similar findings were also reported by Jat *et al.* (2013) and Meena *et al.* (2022). The observed technological gap may be attributed to variations in the soil fertility level, sporadic and uneven rainfall, local weather fluctuations, and farmer management. Therefore, it seems that variety-wise, location-specific recommendations are required to reduce the technological gap for yield level in various scenarios (Jat *et al.* 2021).

Extension gap

The parameter extension gap helps to understand the difference between the yield achieved with the improved technology in the demonstration plots and farmer's practice which is presented in Table 2. The calculated extension gap was 290 kg/ha, 250 kg/ha and 230 kg/ha for the year 2019-20, 2020-21 and 2021-22, respectively. This finding is in corroboration with the findings of Undhad *et al.* (2019), Bharti *et al.* (2024), and Reager *et al.* (2020). The average extension gap was 257 kg/ha which addresses the necessity of educating farmers *via* a variety of channels such as front-line demonstrations, group meetings, field day programs, media coverage etc. to aware the farmers about modern agro-techniques and encourage them the adopt better agricultural production methods and halt the current trend of large extension gap. This worrisome tendency of the galloping extension gap will eventually shift when the most recent production systems with high-yielding variety are used more. Farmers will gradually shift from using outdated technologies to new ones as a result of the arrival of new ones.

Technology index

The feasibility of the improved technology at the farmer's field can be understood from the technology index parameter. The lower the value of the parameter, the higher the efficacy and performance of the technological interventions at the farmer's field, whereas a higher value of the technology index indicates insufficient extension services for the transfer of the technologies. The value of the technology index varied between 18.87% to 20.35% with an average value of 19.39%.

Table 3. Grain yield, technology gap, extension gap, technology index of chickpea under FLD

Year	Variety	Area (ha)	No. of farmers	Grain yield (kg/ha)			% increase over FP	Technology gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
				PY	IT	FP				
2019-20	Pusa 3043	10	20	1700	1378	1088	26.68	322	290	18.94
2020-21	GNG 2207	15	40	1700	1354	1104	22.69	346	250	20.35
2021-22	GNG 2299	15	52	1500	1217	987	23.25	283	230	18.87
Total		40	112							
Average				1633	1316	1060	24.21	317	257	19.39

PY: Potential Yield, IT: Improved Technology, FP: Farmer's Practice

Table 4. Economic analysis of the recommended practices of chickpea under FLD

Year	Variety	Total cost of cultivation (INR/ha)		Gross return (INR/ha)		Net return (INR/ha)		B:C ratio		Surplus cost (INR/ ha)	Surplus returns (INR/ ha)	Surplus gains (INR/ ha)	% increase in net return
		IT	FP	IT	FP	IT	FP	IT	FP				
2019-20	Pusa 3043	35400	30900	67178	53028	31778	22128	1.90	1.72	4500	14150	9650	43.61
2020-21	GNG 2207	35900	31100	69054	56285	33154	25185	1.92	1.81	4800	12769	7969	31.64
2021-22	GNG 2299	36700	32500	63649	51642	26949	19142	1.73	1.59	4200	12007	7807	40.78
Average		36000	31500	66627	53652	30627	22152	1.85	1.70	4500	12975	8475	38.68

PY: Potential Yield, IT: Improved Technology, FP: Farmer's Practice, B:C ratio: Benefit ost ratio

Similar results related tothe technology index were also reported by Prajapati *et al.* (2019).

Economics

To confirm the economic viability of the improved technology over farmer's practice, gross return, net return, and B:C ratio were calculated based on prevailing market prices during the experimentation period which is presented in Table 3. Higher average gross return (INR. 66,627/ha), net return (INR. 30,627/ha), and B:C ratio (1.85) were recorded with improved technology. The total cost of cultivation recorded for variety 'Pusa 3043', 'GNG 2207' and 'GNG 2299' was INR. 35,400/ha, INR. 35,900/ha and INR. 36,700/ha, respectively. Though the total cost of cultivation was slightly higher with improved technology due to the use of different inputs, the gross return was also higher due to a higher grain yield which ultimately resulted in a higher B:C ratio. Net return was increased by an average of 38.68% which also justifies the increased cost of cultivation in improved practices. With only a marginal increase in surplus cost, an average surplus return of INR. 12,975/ha was achieved during these years. These findings conform with Dhakad *et al.* (2022), Yadav *et al.* (2024), Meena *et al.* (2022) and Reager *et al.* (2020).

CONCLUSION

The FLD program created a good opportunity for the researchers to demonstrate the potentiality of the improved technologies in yield enhancement and also helped the farmers realize the yield gap. It also made the farmers aware of the recent varieties and the role of modern agro-technologies in enhancing chickpea yield which may motivate them to adopt these new techniques and upscale the chickpea production of these areas. More extension activities like group meetings, training, and demonstrations might be taken up to disseminate the improved technologies among the farmers. Also, efforts should be made by extension agencies to know the constraints faced by the farmers while adopting different technologies and providing them with effective solutions. The beneficiary farmers of the FLD program also played an important role as a source of different information and suppliers of quality seeds for wider distribution of the high-yielding varieties of chickpea to other nearby farmers.

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