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Improving Rice Productivity and Profitability through Front Line Demonstrations in Eastern-Gangetic Plains of India

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ABSTRACT

On-farm cluster front-line demonstrations (CFLDs) were carried out during *Kharif* season of 2016 and 2017 to assess the impact of Frontline Demonstrations (FLDs) on productivity and profitability of rice crop and improved technologies in different district of Bihar. The CFLDs were conducted by the ICAR-Indian Agricultural Research Institute, Regional Station Pusa, Samastipur, Bihar with the help of KVKs of respective district under the IARI-Outreach Programme to know the yield gap, extension gap, economic return, extent of farmer's satisfaction, and constraints faced by the farmers, especially paddy growers of Bihar. The farmers are trained production technology through personal interaction, discussions with farmers and scientists and group meetings. It was revealed that the demonstrated technologies under FLDs resulted in an augmented mean yield of 4.22 t/ha having an edge of 43.64% higher yield over Local Check (farmer's practice) of 2.94 t/ha. Demonstration technology recorded a mean extension gap (EG) of 1.28 t/ha. The FLDs recorded an additional return of ₹16021.50/ha and ₹17359.00/ha with B: C ratio of 1.47 and 1.36 for demonstration and 1.35 and 1.18 for Local Check during 2016 and 2017, respectively. The lack of improved high-yielding rice varieties was found to be the most difficult constraint. To overcome this problem farmers are advised to adopt new rice varieties as well as recommended improved production technologies to increase the production and productivity of rice in Eastern Gangetic Plains of India.

Keywords: Economics, Extension Gap, FLDs, Improved Technology, Productivity, Rice[1]

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the staple food crops of two billion population of Asia and more than 60-70 percent energy requirement are fulfil from rice and its derived products. It is also known as "Global Food" as more than half of the world's population depends on it for daily energy requirement (FAO 2018). India is one of the major rice growing country having the largest area and contributes 21.5% of the global rice production and stands second after China. The total area under rice cultivation in India is 46.38 mha with a total production of 130.29 mt and productivity of 2.81 t/ha (Agricultural Statistics at a Glance, 2022). Right now, the world population is growing at an alarming rate. However, rice demand is increasing and the estimated increase is 50% in global rice production to meet the requirements of the burgeoning population by 2050, respectively (IRRI, 2020). Adoption of high yielding rice varieties along with improved production technologies is one of the solutions for feeding the world's expanding population.

Rice is one of the major food crops of Bihar. Bihar is the second-largest producer of rice after West Bengal having 2.68 t/ha average productivity which is significantly lower than the national average (Agricultural Statistics at a Glance, 2022). Non-availability and poor-quality seed of newly released varieties, high cost of inputs, poor extension services, erratic rain and power supply, lack of irrigation facilities and poor plant protection measures are the major reasons for low productivity of rice in Bihar. In addition to this declining factor productivity, multi-nutrient deficiencies, soil salinity and alkalinity, the menace of wild animals, and poor knowledge of improved production technologies are also the reasons for poor rice productivity. A wide gap exists in rice production with the use of available technologies which is reflected in the poor yield of rice crops on farmers' fields (Hashim *et al*. 2023b). To overcome this problem, the adoption of improved production technologies is the best option in Bihar. Cluster front-line demonstrations play a very important role in reducing the yield gap as well as increase the production and productivity of rice in the farmer's field.

Frontline demonstration is the concept that involves field demonstration in the farmer's field to identify the constraints

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and potential of the crop in a particular area, as well as the socio-economic characteristics of farmers. Adoption of recent technologies will help in replacement of antiquated technologies/varieties and narrow down the yield gap. Rice productivity and farmer income could be increased by using suitable high-yielding varieties along with the cutting-edge scientific and sustainable production techniques. Keeping in mind the importance of FLDs and the significance of transfer of technology, the ICAR-Indian Agricultural Research Institute, Regional Station, Bihar, laid out demonstrations of rice crops on farmers' fields during the *Kharif* season of 2016 and 2017 in different districts of Bihar under the IARI Outreach Programme.

MATERIALS AND METHODS

To assess the performance of improved varieties of rice as part of the IARI Outreach Program a total of 140 and 150 frontline demonstrations were conducted in 6 and 5 districts of Bihar during the *Kharif* season of 2016 and 2017, respectively through Krishi Vigyan Kendras (KVKs) (Table 1). To reduce the yield gap and to demonstrate the production potential and economic feasibility of improved technologies in farmers' fields, a total of 290 CFLDs were laid out on rice crops in two years. The improved package of practices such as improved variety, seed treatment with fungicide (2.0 gm carbendazim), and inoculation with bio-fertilizers (*Azospirillum* and PSB) were provided to the farmers. The input distributions to the selected farmers through KVKs of respective district for effective execution of FLDs. Farmers were given additional technical assistance regarding the suggested package of practices by IARI, R.S. Pusa Bihar and KVKs. The Scientists and project staff of our institute and KVKs also regularly monitor the farmer's field demonstrations, where growth and yield parameters were recorded. The yield and economics of demonstration and farmers' practice was also recorded and analyzed. The rice crop was transplanted in the first fortnight of July and harvested in the month of April during both the years. Data were collected from each FLD farmer as

Table 2: Comparison of technology gap between Cluster Frontline Demonstrations (CFLDs) and existing farmer's practice (FP)

Particulars	FLDs	Farmers practice (FP)	Technology Gap
Field preparation	Timely	Timely	No gap
Variety	Pusa Sugandha- 5, PNR 381 and Pusa 44	Local/indigenous varieties	Full
Time of nursery raising	Timely	Late sowing (Up toJuly)	Partial
Seed rate	Recommended seed rate (25 kg/ha)	High seed rate	Full
Nursery raising	Scientific method used	Non-scientific	Full
Transplanting and Spacing	Line sowing and maintaining a spacing of 20 × 10 cm	Not maintaining proper spacing	Full
Seed treatment	Seed treatment with fungicides i.e. Carbendazim @ 2 g/kg seed	No seed treatment	Full
Fertilizer application	Recommended fertilizer dose (Fertilizer application @ 150 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare)	Lower rate of fertilizer application without considering the recommended rate	Full
Use of bio-fertilizers	Use of *Azospirillum* and PSB	No use of Bio-fertilizer	Full
Water management	5-6 irrigations (depending on rains)	2 or 3 irrigations only	Partial
Weed management	Pre-emergence application of Pendimethaline and post emergence application of bispyribac sodium (Nomini Gold) @ 25 g/ha	No chemical weed control measures followed	Full
Harvesting and threshing	Harvesting and threshing at the right time	No timely harvesting and threshing	Full

Table 1: List of varieties, districts covered no. of demonstrations given under rice FLDs

Year	Varieties	Districts	State	No. of demonstrations
2016	Pusa 44, PNR 381 and Pusa Sugandha 5	Supaul,Madhepura,Saharsha,Darbhanga,Sitamarhi, Madhubani,	Bihar	140
2017	PNR 381 and Pusa Sugandha 5	Supaul, Madhepura, Saharsha, Darbhanga, Sitamarhi,	Bihar	150

well as from non-FLD farmers for comparison. For the calculation of yield, cost of cultivation, gross returns, net returns, and the B: C ratio, mean values were taken from 290 farmers (140 farmers during 2016 and from 150 farmers during 2017).

To estimate the extension gap and yield gap the following formulae as suggested by Samui *et al*., 2000 were considered which led to the drawing of final conclusions. The following analytical tools were used for assessing the performance of the FLDs on rice crop:

- Extension gap (t/ha) = Demonstration yield – Farmer's practice yield

$$\text{Yield gap (\%)} = \frac{\text{Demontartion yield - Control yield}}{\text{Control yield}} \times 100$$

- Additional cost (₹) = Demonstration cost (₹/ha) – Farmer's practice cost (₹/ha)
- Additional returns (₹) = Demonstration returns (₹/ha)–Farmer's practice returns (₹/ha)
- Effective gain (₹) = Additional returns (₹/ha) – Additional cost (₹/ha)
- Incremental B: C ratio = Additional returns (₹/ha) ÷ Additional cost (₹/ha)

RESULTS AND DISCUSSION

There was wide gap between frontline demonstrations (FLDs) and current farmer's practices (FP) and comparison between them are presented in Table 2. The farmers in the adopted villages were not very much aware with the recommended rice crop production techniques. Farmers of all adopted villages were using local/indigenous varieties; late sowing of nursery, high seed rate, no seed treatment, transplanting without maintaining proper spacing, low fertilizer rate, no use of bio-fertilizer, less number of irrigations, no chemical weed control measures and no timely harvesting and threshing of the mature crops were common practices. According to the information collected from the demonstrated village, there was a complete gap in the use of HYVs, seed rate, nursery raising, transplanting and spacing, seed treatment, fertilizer dose, use of bio-fertilizer, weed management harvesting, and threshing. No gap was observed with respect to field preparation. However, there was a partial gap observed in the time of nursery raising and management of water. These gaps in advanced technology were the main cause of the low yield potential of the rice crop in the demonstration village and the surrounding area (Hashim *et al.* 2023b).

Yield analysis and yield gap

The yield data of the rice crop under FLDs and Non-FLDs plots were recorded during *Kharif* season of 2016 and 2017and are presented in table 3 and 4. From the data it was observed that improved production technology resulted in average yield levels of 4.34 and 4.09 t/ha in comparison to 3.04and 2.83 t/ha under traditional farmers' practice, during 2016 and 2017, respectively. Regarding the performance of rice varieties, the maximum average yield (4.78 t/ha) was recorded with Pusa 44

Table 3: Performance of improved rice varieties against local variety on farmer's field

Year	Name of varieties under CFLDs	No. of demonstrations	Grain yield (t/ha) Improved technology (FLDs) Max.	Avg.	Farmer's practice average yield (t/ha)	Increase in yield over farmer's practice (%	Ext. gap (t/ha)
2016	Pusa 44	140	5.02	4.78	3.25	47.08	1.53
	PNR 381		4.17	3.94	2.85	38.25	1.09
	Pusa Sugandha 5		4.48	4.29	3.03	41.58	1.26
2017	PNR 381	150	4.10	3.90	2.75	41.82	1.15
	Pusa Sugandha 5		4.45	4.27	2.90	47.24	1.37

Table 4: Yield of rice varieties in improved and farmer's practices through frontline demonstration under real farm situation

Year	No of demonstrations	Grain yield (t/ha) Improved technology (FLDs) (mean)	Grain yield (t/ha) Farmer's practice (mean)	Extension gap (t/ha)	Yield gap (%
2016	140	4.34	3.04	1.30	42.76
2017	150	4.09	2.83	1.26	44.52
Mean	145	4.22	2.94	1.28	43.64

variety during the year 2016. However, during 2017 Pusa 44 variety was not given to the farmers so, Pusa Sugandha 5 performed better and produced the higher yield than PNR 381 variety. Further it was also reported that the adoption of improved production technology for rice cultivation is capable of enhancing productivity by 43.64% over Non-FLDs farmer practices. Similar yield enhancement in various crops in front-line demonstration has been extensively documented by Pandey *et al.* (2017), Meena *et al.* (2018), Basediya *et al.* (2023), Girish *et al.* (2020), Singh *et al.* (2018), Suthar *et al.* (2016), Kumar *et al.* (2020), Singh *et al.* (2020), Mauriya *et al.* 2024; Hashim *et al.* 2024; Mauriya *et al.* 2023; Hashim *et al.* 2023a; Hashim *et al.* 2023b; Hashim *et al.* 2022a; Hashim *et al.* 2022b.

It was found that the improved rice variety performed better than the local check. The adoption of a high-yielding improved variety, the recommended and appropriate seed rate, line sowing/transplanting methods, improved production technology, weed control and plant protection measures may all have contributed to the higher yield of rice in different districts of Bihar. These results are supported by Hashim *et al.* 2022 and Hashim *et al*. 2023b.

Extension gap

Extension gap analysis was done for all rice varieties under demonstrations during both the years. A significant extension gap was recorded between the demonstrated technology and farmers' practices (Table 3 and 4). Results demonstrated that an extension gap of 1.30 and 1.26 t/ha was recorded during 2016 and 2017, respectively. So, it is necessary to educate the farmers, provide training and awareness programs to encourage early adoption of improved agricultural production technologies for rice and to narrow down the wide extension gaps. This wide extension gap needs to bring at minimum level. As a result farmers will eventually be convinced to abandon the old practices and adopt the new ones by this new technology. The results of Singh *et al.* (2020), Girish *et al.* (2020), Bhupenchandra *et al*. (2021), Kumar *et al.* (2020), Basediya *et al.* (2023), Mauriya *et al*. 2024; Hashim *et al*. 2024; Mauriya *et al*. 2023; Hashim *et al*. 2023a; Hashim *et al*. 2023b; Hashim *et al*. 2022a; Hashim *et al*. 2022 bare in agreement with this finding.

Economic analysis

On the basis of the prevailing market prices of inputs and outputs, the economic evaluation was made. The economic performance of demonstrated technologies over farmer's practices was computed based on prevailing prices of inputs and outputs costs (Table 5 and 6). Perusal to data depicted in Table 5 and 6 reveals the economic performance of the new rice variety along with recent production technologies as compared to local which recorded higher yield as compared to local. From the two years study (2016 and 2017) it was revealed that higher mean cost of cultivation of 41190 /ha of demonstrated technology was recorded in 2017 while it was 40289 /ha in

Table 5: Detailed comparative analysis of the demonstrated technology and farmer's practice on economic performance of rice

Year	Cost of cultivation (? /ha)		Net returns (? /ha)		B: C ratio		Additional cost (? /ha)	Additional net returns (? /ha)	Additional gain (?)	Incremental B: C ratio
	FLDs	Local check	FLDs	Local check	FLDs	Local check				
2016	40289.00	31924.00	59185.50	43164.00	1.47	1.35	8365.00	16021.50	7656.50	1.92
2017	41190.00	32800.00	56096.50	38737.50	1.36	1.18	8390.00	17359.00	8969.00	2.07
Mean	40739.50	32362.00	57641.00	40950.75	1.42	1.27	8377.50	16690.25	8312.75	1.99

Table 6: Comparative economics of rice improved technology and farmer's practices

Particulars	Improved technology	Farmer's practice	Actual increase over farmer's practice	Increase over farmer's practice (%)
Average yield (t/ha)	4.22	2.94	1.28	43.64
Cost of cultivation (? /ha)	40739.50	32362.00	8377.50	25.89
Net return (? /ha)	57641.00	40950.75	16690.25	40.76
B: C ratio	1.42	1.27	0.15	11.81

2016 as against cost involved in local check of 32800 /ha and 31924 /ha during 2017 and 2016, respectively. The FLDs recorded higher mean net returns 59185.50 /ha and 56096.50 /ha with higher benefit: cost ratio of 1.47 and 1.36 as compared to mean net returns of 43164.00 /ha and 38737.50 /ha and benefit: cost ratio of 1.35 and 1.18 during 2016 and 2017, respectively of local check. Our results are also in concordance with the findings of Kumar *et al*. (2020), Hashim *et al.* (2023), Mauriya *et al*. 2024; Hashim *et al*. 2023b; Hashim *et al*. 2022b.

The highest additional cost (8390.00 /ha), additional net returns (17359.00 /ha), additional gain (8969.00 /ha) generated from demonstrated field was reported during the year 2017 and lowest additional cost (8365.00 /ha), additional net returns (16021.50 /ha), additional gain (7656.50 /ha) was recorded in 2016. Finally, the highest incremental B: C ratio was observed in 2017 (2.07) and lowest was recorded in 2016 (1.92). Singh *et al*. (2020), Meena *et al*. (2018), Basediya *et al*. (2023), Kumar *et al*. (2020), Girish *et al*. (2020), Singh *et al*. (2018), Mauriya *et al.* 2024, Hashim *et al.* 2024, Mauriya *et al.* 2023, Hashim *et al.* 2023a, Hashim *et al.* 2023b, Hashim *et al*. 2022a and Hashim *et al.* 2022b also reported the same results.

Feedback of the farmers and extent of farmer's satisfaction

The precise technologies that had been tried and proven to work for their fields were convinced to be adopted by the farmers in the adopted village. They welcome the adoption of new varieties and technologies. The improved, proven variety was superior to the old or check varieties. The technology that was demonstrated and the degree of yield satisfaction received positive feedback from the nearby farmers. The majority of farmers believe that if input support is stopped, they will adopt proven technologies. The level of satisfaction with the support provided was also satisfactory (Table 7).

Table 7: Feedback of the farmers

Particulars	Feedback
Benefits of the demonstrated rice variety in comparison to local one	Beneficial
Response of the neighbouring farmers to the FLDs	Positive
Yield satisfaction level	Very high
Will the farmer adopt the proven technologies in the event that input support is discontinued?	Yes
Level of satisfaction with the support provided	Satisfactorily

Table 8: Extent of Farmer's Satisfaction about Front Line Demonstration (N= 145)- Average of two years

Satisfaction Level	Frequency	Percentage
Low	13	9
Medium	21	14
High	111	77

Table 8 displays the degree of farmer satisfaction with front-line demonstrations. Most farmers expressed high (77%) and medium (14%) levels of satisfaction regarding the performance of FLDs, while only a small percentage (9%) expressed a lower level of satisfaction. This suggests that farmers have stronger convictions and are more physically and mentally involved in the front-line demonstrations, which will lead to higher adoption

CONCLUSION

The rice FLDs conducted in different districts of Bihar had made an impact on both participant and -non participant farmers. The level of adoption of participant farmers regarding improved practices of rice was higher than non-participant. The farmer's attitudes changed as a result of the FLD program. From the study it is clearly suggest that improved technologies are more profitable and productive than traditional practices. The FLDs significantly reduced the extension and yield gap and played an important role in motivating farmers for adoption of improved agricultural practices and improve their standard of living. Therefore, it is essential to share the new production technologies with farmers through FLDs and other efficient extension methods in order to raise their standard of living. There should be direct involvement of extension agencies in creating awareness about the new technology and recent released varieties along with other input support in order to ensure higher adoption of technologies by the farming community.

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Conflict of interest

The authors declare no conflicts of interest

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