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Bridging yield gaps in late-sown wheat: Evidence from frontline demonstrations in Haryana

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Abstract
The study was conducted over a period of three years, from Rabi 2019-20 to 2021-22, on farmers' fields in Faridabad district, Haryana. Frontline demonstrations were carried out with the objective of evaluating the productivity and profitability of late-sown wheat varieties under the paddy-wheat cropping system. The results clearly indicated that the demonstrations using improved practices consistently recorded higher grain yields compared to the traditional farmer's practices, which involved older wheat varieties. The improved variety WH 1124 showed a progressive increase in grain yield, ranging from 42.30 to 47.80 q/ha, reflecting a yield advantage of 8.2% to 13.0% over the farmer's practice across the three years. Alongside yield enhancement, the study observed a mean extension gap of 3.94 q/ha, technology gap of 5.92 q/ha, and a technology index of 10.76%. These findings suggest that promoting improved wheat cultivation practices can significantly reduce the yield gap under late-sown conditions in the region. Moreover, the improved variety WH 1124 also demonstrated higher gross and net returns and a better benefit-cost ratio compared to traditional practices. Overall, the study concludes that WH 1124 is a suitable and profitable option for late-sown wheat under the paddy-wheat cropping system in Faridabad district.

Keywords: Cropping sequence, demonstration, fertilizer use, paddy, wheat

Introduction
Wheat (*Triticum aestivum* L.) is the second most important cereal crop both globally and in India. In India, the majority of the wheat-growing area lies within the Indo-Gangetic Plains (IGP), covering approximately 20 million hectares across the states of Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. Among these, Punjab and Haryana contribute significantly to the national wheat buffer stock, a vital component of the country's food security (Agricultural Statistics at a Glance, 2021) [1].

In Faridabad district of Haryana, wheat is the predominant Rabi crop, occupying over 30,000 hectares out of the total 36,000 hectares of cultivated land. As the principal crop of the winter season, wheat has specific requirements for temperature and light for optimal emergence, growth, and flowering. Several factors contribute to the low productivity of wheat, among which late sowing caused primarily by the harvesting of paddy in November is a major concern. The selection of appropriate crop varieties suited to local agro-climatic conditions plays a crucial role in achieving optimal yields (Singh *et al*., 2017) [4]. Early sowing under ideal temperature conditions promotes better growth and nutrient uptake, while delayed sowing can lead to significant yield losses. High-yielding varieties are essential for enhancing productivity during the optimum growing season (Reager *et al*., 2018) [2]. Frontline demonstrations are essential components of agricultural extension programs, serving as practical platforms for showcasing improved agricultural technologies to farmers (Desai *et al*., 2021) [3]

To address these challenges, Krishi Vigyan Kendra, Faridabad has been actively promoting and popularizing improved wheat varieties throughss frontline demonstrations. This initiative was introduced to encourage the adoption of improved production technologies and to maximize yields under actual farm conditions. The objectives of the program include expanding the cultivation of improved varieties, collecting feedback from farmers, identifying constraints in the adoption of recommended practices, and enhancing technology dissemination.

Frontline demonstrations serve as an effective tool to display relevant technologies at farmers' fields under the close supervision of agricultural experts. This approach significantly reduces extension and technology gaps (Singh *et al*., 2017) [4]. In this context, the present study was undertaken to assess the productivity and profitability of late-sown wheat under the paddy-wheat cropping system through frontline demonstrations conducted on farmers' fields.

Materials and Methods

The study was carried out by Krishi Vigyan Kendra, Faridabad of Haryana, during Rabi 2019-20 to 2021-22 at farmers' fields. Participating farmers were selected and trained on various aspect of wheat production during these three years of study, total 70 frontline demonstrations were carried out covering 32 ha area with active participation of farmers. In general, soils of the area under study were light to medium in texture particularly sandy loam, sandy with low fertility status in Nitrogen and Phosphorus and medium to high in Potash. The average rainfall of this area was 515 mm.

The farmers were trained with various training programmes on scientific package of practices of wheat production under late sown conditions. In demonstration plots, all the agronomic practices including use of quality seeds of improved variety (WH 1124), line sowing, seed treatment and effective weed management as well as recommended dose of fertilizers were emphasized as per package of practices for wheat crop and providing irrigation to the crop during its critical growth stages and then comparison has been made between improved practices and the existing practices at farmer's field. (Table 1). The data on output were collected from FLDs plots as well as local check plots and finally the grain yield, cost of cultivation, gross return, net returns with the benefit cost ratio worked out. The extension gap, technology gap and technology index were calculated by using formulas as given by Samui *et al* (2000) [5].

The formula used for calculating the aforesaid data was as follows

Technology gap = Potential yield- Demonstration yield

Extension gap = Demonstration Yield-Farmers yield

$$\text{Technology index (\%)} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100$$

Table 1 highlights the key differences between Improved Practices (IP) adopted under Frontline Demonstrations (FLDs) and the conventional Farmer's Practices (FP) for late-sown wheat cultivation. Both approaches are practiced under irrigated conditions and follow paddy as the previous crop. However, significant differences exist in crop management strategies.

Under IP, the high-yielding wheat variety WH 1124 is used, whereas FP involves the older variety WH 1021. Seed treatment is a major improvement in IP, where seeds are treated with Tebuconazole fungicide at 1 g/kg and inoculated with biofertilizers like Azotobacter and PSB, which is not practiced in FP. Sowing is done earlier in IP (5th to 15th December), enabling better crop establishment compared to FP (20th to 30th December). The seed rate in IP (125 kg/ha) is more optimal than the excessive rate used in FP (150-160 kg/ha).

Fertilizer application in IP (120:40:30:25 kg NPK Zn/ha) is balanced and includes zinc, whereas FP uses a higher nitrogen dose with no potash and improper zinc usage. Weed management in IP uses a ready-mix herbicide, while FP applies separate herbicides. Finally, IP employs need-based insecticide application per university recommendations, unlike FP where no plant protection measures are adopted.

Results

Productivity

The average yield under IP significantly outperformed the average yield of Farmer's Practices (FP). The yield increase over FP with a mean increase of 10.25%.

Gap analysis

The extension gap varied from 3.20 to 5.50 q/ ha during the period of study emphasizes the need to educate the farmers through various means for adoption of improved agricultural production technologies. The technology gap was highest during 2021-22 and lowest in the year of 2020-21. The minimum technology index value of 14.7 per cent reported during 2020-21 followed by 20.49 in the year of 2019-20 whereas maximum value of technology index of 24.59 was reported in the year of 2021-22.

Economics

The economic analysis clearly indicates that adopting improved wheat cultivation practices under FLDs significantly enhances profitability without incurring additional costs, making it a viable and beneficial option for farmers in late-sown conditions.

Discussion

Productivity

Table 2 presents data from frontline demonstrations (FLDs) of late-sown wheat over three Rabi seasons (2019-20 to 2021-22), focusing on yield performance, adoption gaps, and technology efficiency. Across all three years, the variety WH 1124 was used under improved practices (IP). The demonstrations covered a total of 32.0 hectares with 70 demonstrations.

The average yield under IP was 44.9 q/ha, which significantly outperformed the average yield of 40.7 q/ha under Farmer's Practices (FP). The yield increase over FP ranged from 8.18% to 13.00%, with a mean increase of 10.25%. Similar yield enhancement in different crops in FLDs has been reported by Prajapati *et al*. (2019) [6], Undhad *et al*. (2019) [7]. This indicates the effectiveness of improved practices in enhancing productivity under late-sown conditions.

Gap analysis

Extension gap

The extension gap, which reflects the difference between IP and FP yields, averaged 4.2 q/ha—highlighting the yield advantage farmers can achieve by adopting improved technologies. The data (Table 2) varied from 3.20 to 5.50 q/ ha during the period of study emphasizes the need to

educate the farmers through various means for adoption of improved agricultural production technologies to reverse the trend of wide extension gap.

Technology gap

The technology gap, which is the difference between potential and demonstration yield was highest during 2021-22 (13.8 q/ha) and lowest in the year of 2020-21 (8.3 q/ha). However, overall mean of technology gap during the study was 11.2 q/ha. The variation in technology gap observed may be attributed to the dissimilarity in soil fertility status and weather condition prevails during the study. Mukharjee (2003) [8] was also explained that depending on identification and use of farming situation, specific interventions may have greater implications in enhancing system productivity.

The technology gap, the shortfall from the potential yield (assumed here to be 56.1 q/ha), averaged 11.2 q/ha, showing scope for further improvement. The technology index, representing the gap as a percentage of the potential, averaged 19.92%, suggesting moderate efficiency of the demonstrated technologies.

Overall, the FLDs significantly improved yield and demonstrated the potential for narrowing gaps through better practices and technology dissemination among farmers.

Technology index

The technology index for all the demonstrations during different year were in accordance with technology gap. Technology index shows the feasibility of the technology at farmers' fields. The lower the value of technology index means more is the feasibility of the technology (Mokidue *et al*. (2011) [9]. It was revealed that minimum technology index value of 14.7 per cent was reported during 2020-21 followed by 20.49 in the year of 2019-20 whereas maximum value of technology index of 24.59 was reported in the year of 2021-22. These finding were in close conformity of Prajapati *et al*. (2019) [6], Chourasiya *et al* (2022) [10] in wheat, Kumar *et al* (2024) [11] in moong and Yadav *et al* (2025) [12] in mustard.

Table 3 outlines the economic benefits of Improved Practices (IP) over Farmer's Practices (FP) in late-sown wheat cultivation under Frontline Demonstrations (FLDs) for three consecutive Rabi seasons. The data includes cost of cultivation, gross and net returns, and the benefit-cost (B:C) ratio.

The cost of cultivation remained similar between IP and FP across all years, averaging ₹36,600/ha for IP and ₹36,433/ha for FP, showing that improved practices did not significantly increase production costs. However, the gross returns were notably higher in IP, with an average of ₹1,15,377/ha compared to ₹1,04,947/ha in FP. This led to a substantial increase in net returns, averaging ₹78,777/ha for IP versus ₹68,514/ha for FP.

The B:C ratio, which indicates profitability, was consistently higher under IP across all years. The average B:C ratio was 3.15 under IP, compared to 2.88 under FP, demonstrating that every rupee invested yielded greater returns with improved practices.

In conclusion, the economic analysis clearly indicates that adopting improved wheat cultivation practices under FLDs significantly enhances profitability without incurring additional costs, making it a viable and beneficial option for farmers in late-sown conditions. These lines were in the findings of Singh (2017) [4], Chourasiya *et al* (2022) [10] and Kumar *et al* (2024) [11].

Table 1: Comparisons between Improved Practices (IP) and Farmer's Practices (FP) under late sown Wheat frontline demonstrations.

Sr. no.	Particular	Improve Practices (FLDs)	Farmers Practice (Existing practices)
1.	Farming situation	Irrigated	Irrigated
2.	Previous crops	Paddy	Paddy
3.	Variety	WH 1124	WH 1021
3.	Seed treatments	Seed treatment with fungicide Tebuconazole 2 DS at 1 g/kg seed followed by biofertilizers *Azotobacter* and PSB culture	Nil
4.	Time of sowing	5th December to 15th December	20th December to 30th December
5	Seed rate	125 kg/ha	150-160 kg/ha
6.	Fertilizers dose	120:40:30:25 kg NPK Zn/ha	150-160:30-40:0:15-20 kg NPKZn/ ha
7	Weeds management	Sulfosulforon 75 % + Metsulfuroun methyl 5 % WG (ready mix) 32 g a.i./ha at 30-35 DAS	Sulfosulforon 75 % at 30-35 days after sowing (DAS)f.b 2,4-D at 0.50 kg a.i./ha after one week of 1st spray
8	Plant protection measure	Need based application of insecticides as per university recommendation.	Nil

Table 2: Details of acreage, yield, per cent increase in yield, extension gap, technology gap and technology index under late sown Wheat frontline demonstrations

Season & year	No. of Demo.	Area (ha)	Variety	Yield (q/ha)		Per cent increase in yield over FP	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
				IP	FP				
Rabi 2019-20	20	12.0	WH 1124	44.6	40.7	9.58	3.9	11.5	20.49
Rabi 2020-21	20	8.0	WH 1124	47.8	42.3	13.00	5.5	8.3	14.7
Rabi 2021-22	30	12.0	WH 1124	42.3	39.1	8.18	3.2	13.8	24.59
Total/ Mean	70	32.0	-	44.9	40.7	10.25	4.2	11.2	19.92

IP: Improved Practices *i.e.* FLD; FP: Farmers' Practice

Table 3: Economics under late sown Wheat under frontline demonstration.

Year	Cost of cultivation Rs/ha		Gross Return Rs/ha		Net Return Rs. /ha		B:C Ratio	
	IP	FP	IP	FP	IP	FP	IP	FP
Rabi 2019-20	35800	35800	108855	101350	73055	65550	3.04	2.83
Rabi 2020-21	36750	36750	132040	114705	95290	77955	3.59	3.12
Rabi 2021-22	37250	36750	105235	98786	67985	62036	2.83	2.69
Mean	36600	36433	115377	104947	78777	68514	3.15	2.88

Conclusion

The study demonstrates that the adoption of improved wheat variety WH 1124 along with recommended agronomic practices under frontline demonstrations significantly enhances productivity and profitability in late-sown conditions of the paddy-wheat cropping system in Faridabad district. The improved practices consistently outperformed traditional farmer practices, with notable gains in yield, gross and net returns, and benefit-cost ratios. The reduction in extension and technology gaps further validates the effectiveness of frontline demonstrations in promoting technology adoption. Therefore, scaling up such demonstrations and promoting high-yielding, climate-suited varieties can substantially boost wheat production and farmer income under late sowing conditions.

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