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Performance evaluation of super seeder technology for wheat sowing under paddy residue in district Panipat, Haryana

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Abstract

This study, conducted by CCS Haryana Agricultural University (HAU) Krishi Vigyan Kendra, Panipat, under the project "Promotion of agricultural mechanization for in-situ management of crop residue" coordinated by ICAR-Agricultural Technology Application Research Institute Zone-II (ATARI-II), Jodhpur, evaluated the performance of Super Seeder technology for wheat sowing under paddy residue over two consecutive seasons (2022-2023 and 2023-2024). The Super Seeder demonstrated superior performance compared to the conventional rotavator method, achieving an average wheat yield of 22.0 q/acre versus 21.3 q/acre, reducing the cost of cultivation to Rs. 14,739 per acre compared to Rs. 15,396, and increasing net income to Rs. 37,043 per acre from Rs. 34,983. The benefit-cost ratio also improved from 3.28 to 3.52. Block-wise results confirmed the technology's adaptability across diverse agro-ecological conditions in Panipat district. These findings demonstrate that Super Seeder technology is a cost-effective, profitable, and environmentally sustainable alternative for wheat cultivation under paddy residues, supporting sustainable intensification and climate resilience in the region.

Keywords: Super seeder technology, wheat sowing, paddy residue management, Economic and agronomic performance

Introduction

Wheat cultivation following paddy harvest poses considerable challenges, particularly in managing the substantial volume of paddy residue left in the fields. Conventional residue management practices, such as burning or removal through tillage, have been widely adopted but are increasingly recognized for their detrimental environmental and agronomic impact (Gatkal *et al.*, 2022) [4]. Residue burning contributes significantly to air pollution, greenhouse gas emissions, and the loss of valuable soil organic matter, whereas intensive tillage disrupts soil structure, reduces moisture retention, and adversely affects soil microbial communities (Chaudhary & Soni, 2020; Mathur & Srivastava, 2018; Singh *et al.*, 2023) [3, 9, 10]. These factors collectively undermine soil health and long-term agricultural sustainability, thereby threatening the productivity and resilience of wheat cropping systems in the region.

In this context, super seeder technology has emerged as a promising alternative to traditional tillage methods. It enables the direct sowing of wheat seeds into standing paddy residues without prior tillage or residue removal. This mechanized approach circumvents the need for residue burning, conserves soil moisture, enhances organic matter retention, and promotes microbial activity, thereby fostering a more sustainable agroecosystem. The ability of the Super Seeder to integrate residue retention with crop establishment aligns with the principles of conservation agriculture, supporting sustainable intensification by improving resource-use efficiency and minimizing environmental degradation (Kathpalia *et al.*, 2023, 2024; Kumar Joshi *et al.*, 2025) [5, 6, 8].

The Panipat district, with its diverse agro-ecological zones and significant wheat production, presents an ideal setting for evaluating the practical applicability and benefits of Super Seeder technology under local farming conditions. Despite the recognized potential of zero tillage methods, there remains a paucity of comprehensive, location-specific data assessing their

agronomic performance, economic viability, and adaptability. Addressing this knowledge gap is critical for informed decision-making by farmers, extension agents, and policymakers aiming to promote sustainable wheat cultivation practices in the region. This study systematically investigated the performance of Super Seeder technology for wheat sowing under paddy residue in the Panipat district over two consecutive cropping seasons (2022-2023 and 2023-2024). By conducting a comparative evaluation against the conventional rotavator method, this study examined key agronomic parameters, including wheat yield, cost of cultivation, gross and net income, and benefit-cost ratios. The analysis was extended to block-wise assessments within the district, capturing variability in agro-ecological conditions and management practices to evaluate the technology's robustness and adaptability.

Furthermore, this study explored the broader environmental implications of adopting Super Seeder technology, particularly its role in reducing residue burning and enhancing soil health indicators, such as organic matter content and moisture conservation. These factors are critical for promoting climate-resilient agricultural systems capable of sustaining productivity under increasing environmental stress.

Through empirical data and economic analysis, this study aims to provide a comprehensive evidence base demonstrating the agronomic and economic advantages of Super Seeder technology. The findings are intended to guide farmers in adopting more sustainable residue management and wheat sowing practices, while informing policymakers and stakeholders of effective strategies to support sustainable intensification and environmental stewardship in the region's wheat production systems. Ultimately, this study contributes to advancing sustainable agriculture by promoting innovative technologies that balance productivity, profitability, and ecological health in wheat cultivation under paddy residue retention.

Materials and Methods

The frontline demonstrations for evaluating the Super Seeder technology for wheat sowing under paddy residue were conducted under the project titled "Promotion of agricultural mechanization for in-situ management of crop residue," coordinated by ICAR-Agricultural Technology Application Research Institute Zone-II (ATARI-II), Jodhpur. These demonstrations were implemented, across different blocks of Panipat, by the CCS HAU Krishi Vigyan Kendra, Panipat.

The study was conducted in District Panipat, Haryana, located between latitudes 29°09'50" N and 30°15'15" N and longitudes 76°10'10" E to 77°17'05" E. The region lies in the Indo-Gangetic Plains, characterized by a flat terrain with slight slopes running from the northeast towards the south and southwest. The soils in the area are alluvial, ranging from sandy loam to clay loam, with plain topography and river basins. The district benefits from assured irrigation facilities through canals and tubewells. The climate is subtropical, with monsoonal rainfall concentrated in July, August, and September. Temperature extremes occur, with maximum temperatures reaching up to 46°C during May and June, while winters are cold, with January temperatures occasionally dropping to freezing and frost. Humidity varies seasonally, with minimum levels below 20% during April and May and high humidity during the monsoon period. The major crops include rice, wheat, and sugarcane. Although the land is productive, the overexploitation of natural resources is a concern.

A total of 500 frontline demonstrations were conducted over two

consecutive wheat cropping seasons in the study area. In the 2022-2023 season, 250 demonstrations were carried out using the wheat variety WH 1184, while in the 2023-2024 season, another 250 demonstrations were conducted with the wheat variety DBW 222. These demonstrations involved sowing wheat seeds directly into standing paddy residue using Super Seeder technology, which enables wheat sowing without prior removal or burning of crop residue.

Wheat yield was recorded from each demonstration plot by harvesting the crop at maturity and measuring the grain weight per acre, expressed in quintals per acre (q/acre). Yield data were collected across multiple blocks within the Panipat district to capture variability in the agroecological conditions.

The economic analysis included the calculation of the cost of cultivation, gross income, net income, and benefit-cost (B:C) ratio for each demonstration. The cost of cultivation encompassed all input costs, such as seeds, fertilizers, labor, fuel, and machinery operation associated with wheat sowing and crop management. Gross income was calculated by multiplying the wheat yield by the prevailing market price of wheat grains for the respective year. Net income was derived by subtracting the cost of cultivation from gross income. The benefit-cost ratio was computed as the ratio of gross income to the cost of cultivation, reflecting the profitability of the Super Seeder technology compared to the traditional Rotavator method.

Data from all frontline demonstrations were aggregated and analyzed to compare the agronomic and economic performance of the Super Seeder technology with conventional residue management and sowing practices. Block-wise and district-level averages, minima, and maxima were computed to assess the adaptability and economic viability of the technology under local farming conditions in the study area.

Results

The evaluation of Super Seeder technology for wheat sowing under paddy residue in Panipat district over 2022-2023 and 2023-2024 demonstrated consistent superiority over the traditional Rotavator method in yield, cost, economic returns, and profitability, with clear block-wise and district-level comparisons highlighting the adaptability and robustness of the technology (Tables 1, 2, and 3).

Wheat Yield

Across all blocks and years, the Super Seeder outperformed the rotavator. In 2022-2023 (Table 1), average yields with the Super Seeder ranged from 19.6 q/acre in Bapoli to 21.0 q/acre in Panipat and Madlauda, surpassing the Rotavator yields of 18.9 to 20.3 q/acre in the same blocks. Ishrana and Panipat & Madlauda blocks recorded the highest yields with the Super Seeder, reaching a maximum of 23.1 and 22.0 q/acre, respectively, compared to the Rotavator maximum yields of 22.4 and 21.5 q/acre. In 2023-2024 (Table 2), yield improvements were more pronounced, with Super Seeder averages between 23.2 q/acre (Bapoli) and 23.8 q/acre (Ishrana and Panipat & Madlauda), which were consistently higher than the Rotavator yields of 22.6 to 23.2 q/acre. Maximum yields peaked at 25.0 q/acre with the Super Seeder in Ishrana and Bapoli, compared to 24.0 q/acre with the Rotavator. The district-wide average yield over two years was 22.0 q/acre for the Super Seeder, a 3-4% increase over the Rotavator's 21.3 q/acre (Table 3).

Cost of Cultivation

The Super Seeder reduced the cultivation costs across all blocks in both years. In 2022-2023 (Table 1), costs ranged from Rs.

14,865 to Rs. 14,903 per acre under the Super Seeder, consistently lower than the Rotavator’s Rs. 15,642 to Rs. 15,669. The Bapoli and Ishrana blocks exhibited the lowest costs with the Super Seeder. In 2023-2024 (Table 2), the cost advantage persisted, with Super Seeder costs between Rs. 14,485 and Rs. 14,738 versus Rs. 15,120 to Rs. 15,172 for the Rotavator. Samalkha showed the greatest cost differential, indicating a higher savings potential. The overall district average cost of cultivation was Rs. 14,739 per acre for the Super Seeder compared to Rs. 15,396 for the Rotavator over two years (Table 3).

Economic Returns

Gross and net incomes were consistently higher with the Super Seeder across all the blocks and years. In 2022-2023 (Table 1), Ishrana led with a gross income of Rs. 48,075 and net income of Rs. 33,230 per acre using the Super Seeder, outperforming the Rotavator’s Rs. 46,542 and Rs. 30,909, respectively. Panipat, Madlauda, and Samalkha followed similar patterns. In 2023-2024 (Table 2), the economic advantage increased, with Ishrana again achieving the highest gross income (Rs. 57,231) and net income (Rs. 42,746) under the Super Seeder, exceeding the corresponding figures for the Rotavator. The district-wide average net income over two years was Rs. 37,043 per acre with the Super Seeder, compared to Rs. 34,983 with the rotavator (Table 3).

Benefit-cost (B:C) ratio

The Super Seeder showed superior profitability in all blocks. In 2022-2023 (Table 1), Ishrana recorded the highest B:C ratio for the Super Seeder at 3.24, compared to 2.97 for the Rotavator. Other blocks ranged from 3.04 to 3.23 for the Super Seeder, always exceeding the 2.80 to 2.98 of the rotavator. In 2023-2024 (Table 2), the Super Seeder’s B:C ratio further improved, with Ishrana reaching 3.95 and Samalkha reaching 3.92, while the Rotavator’s best was 3.69 (Ishrana). The overall two-year district average B:C ratio was 3.52 for the Super Seeder and 3.28 for the Rotavator (Table 3), indicating better economic sustainability for the former.

Block-wise Variability and Adaptability

The Super Seeder consistently recorded higher minimum and maximum values for yield, income, and B:C ratio across blocks, demonstrating stable performance under diverse field conditions. Ishrana and Panipat & Madlauda blocks showed the highest maximum yields (up to 25.0 q/acre) and economic returns, suggesting favorable agro-ecological conditions or management practices in these blocks. Bapoli and Samalkha, while slightly lower in maximum values, still showed significant improvements over the Rotavator, confirming the technology’s broad adaptability (Tables 1 and 2).

Discussion

The evaluation of Super Seeder technology for wheat sowing under paddy residue in the Panipat district during 2022-2023 and 2023-2024 reveals significant agronomic and economic advantages over the traditional rotavator method. The consistent superiority of the Super Seeder across multiple performance parameters—yield, cost of cultivation, economic returns, and benefit-cost ratio—demonstrates its effectiveness and adaptability to local agroecological conditions. Wheat yield data clearly indicated that the Super Seeder enhanced productivity. Across all blocks and both years, the average yields with the Super Seeder were consistently higher than those achieved with the Rotavator. Notably, blocks such as Ishrana and Panipat & Madlauda recorded the highest yields, with maximum values reaching 25.0 q/acre in 2023-2024, surpassing the Rotavator yields by a measurable margin. This yield improvement, ranging from approximately 3-4% district-wide over two years, suggests that the Super Seeder’s residue retention mechanism positively influences crop establishment and growth, likely due to better soil moisture conservation and reduced soil disturbance. These results are in corroborated with Bishnoi *et al.*, 2023 ^[1], Kathpalia *et al.*, 2023 ^[5], and Kumar Joshi *et al.*, 2025 ^[8].

The cost of cultivation was uniformly lower with the Super Seeder across all blocks and years. Savings ranged from Rs. 600 to Rs. 900 per acre compared to the rotavator, with the greatest cost differentials observed in blocks such as Samalkha. This reduction in costs can be attributed to the decreased fuel consumption, labor, and time requirements inherent in zero-tillage technology. The economic benefit of reduced input costs, combined with higher yields, translated into consistently higher gross and net income for farmers using the Super Seeder. Similar findings were reported by Bishnoi *et al.*, 2023 ^[1] and Kathpalia *et al.*, 2026 ^[7]. The Ishrana block, in particular, demonstrated the highest net income gains, reinforcing the technology’s profitability under favorable management and environmental conditions.

Profitability analysis via the benefit-cost (B:C) ratio further supports the economic viability of super seeders. Across both years, the Super Seeder’s B:C ratio exceeded that of the Rotavator in all blocks, with district averages of 3.52 versus 3.28. These results are corroborated with findings of Bishnoi *et al.*, 2024 ^[2]; Kumar Joshi *et al.*, 2025 ^[8]. The upward trend in B:C ratios over the two-year period indicates increasing returns on investment and suggests that farmers adopting this technology can expect sustainable economic benefits.

Block-wise variability highlights the robustness and adaptability of Super Seeder technology. While Ishrana and Panipat & Madlauda blocks showed the highest yield and income maxima, other blocks such as Bapoli and Samalkha also recorded significant improvements relative to the Rotavator. This suggests that the Super Seeder performs well under diverse field conditions, making it a broadly applicable solution for wheat sowing under paddy residues in the district.

Table 1: Performance of wheat crop (var. WH 1184) sown with super seeder under paddy residue during 2022-2023.

	Yield (q/acre)		Economics of demonstration (CRM Demo)				Economics of control/Check (Rotavator)			
	CRM Demons (Super Seeder)	Check (Rotavator)	Cost of cultivation (Rs./acre)	Gross income (Rs/ac)	Net income (Rs/ac)	B:C ratio	Cost of cultivation (Rs./ac)	Gross income (Rs./ac)	Net income (Rs/ac)	B:C ratio
Block Bapoli										
Average	19.6	18.9	14865	45219	30353	3.04	15651	43841	28189	2.80
Minimum	18.0	17.4	14255	41850	27326	2.51	15103	40575	24856	2.27

Maximum	21.3	20.7	18558	48863	33757	3.31	19544	47588	31718	3.03
Block Ishrana										
Average	20.9	20.2	14879	48075	33230	3.24	15665	46542	30909	2.97
Minimum	18.0	17.4	14251	41850	27326	2.51	15103	40575	24856	2.27
Maximum	23.1	22.4	18558	52688	37886	3.56	19544	51200	35480	3.26
Block Panipat & Madlauda										
Average	21.0	20.3	14903	48207	33304	3.23	15669	46631	30963	2.98
Minimum	19.0	18.4	14553	43975	29422	3.02	15322	42700	27286	2.77
Maximum	22.0	21.5	15401	50350	35357	3.40	15945	49288	33539	3.18
Block Samalkha										
Average	20.5	19.8	14853	47220	32367	3.18	15640	45683	30043	2.92
Minimum	19.0	18.1	14186	43975	28904	2.92	15119	42063	26470	2.70
Maximum	21.8	21.4	15347	49925	35235	3.43	15990	49075	33423	3.18
Over all District (Average of all the blocks)										
Average	20.4	19.7	14860	47009	32149	3.17	15642	45507	29865	2.91
Minimum	18.0	17.4	14186	41850	27326	2.51	15103	40575	24856	2.27
Maximum	23.1	22.4	18558	52688	37886	3.56	19544	51200	35480	3.26

Table 2: Performance of wheat crop (var. DBW 222) sown with super seeder under paddy residue during 2023-2024.

	Yield (q/acre)		Economics of demonstration (CRM Demo)				Economics of control/Check (Rotavator)			
	CRM Demons (Super Seeder)	Check (Rotavator)	Cost of cultivation (Rs./acre)	Gross income (Rs/ac)	Net income (Rs/ac)	B:C ratio	Cost of cultivation (Rs./ac)	Gross income (Rs./ac)	Net income (Rs/ac)	B:C ratio
Block Bapoli										
Average	23.2	22.6	14731	55697	40966	3.78	15120	54413	39293	3.60
Minimum	20.7	21.2	13518	49935	36177	3.48	14786	50983	35461	3.28
Maximum	25.0	24.0	15461	59905	45410	4.16	15615	57792	42951	3.90
Block Ishrana										
Average	23.8	23.2	14485.03	57231	42746	3.95	15170	55929	40759	3.69
Minimum	22.0	21.5	13639	52818	38735	3.63	14832	51705	36705	3.44
Maximum	25.0	24.0	15410	59929	45319	4.22	15615	57792	42936	3.89
Block Panipat & Madlauda										
Average	23.8	23.2	14738	57155	42417	3.88	15130	55715	40585	3.68
Minimum	21.2	21.9	14122	51056	36931	3.61	14513	52691	37232	3.41
Maximum	24.9	24.0	15457	59833	45066	4.10	15678	57720	42890	3.92
Block Samalkha										
Average	23.7	23.1	14572	56953	42381	3.92	15172	55645	40473	3.67
Minimum	20.6	21.4	12288	49406	36778	3.53	14637	51392	36294	3.34
Maximum	24.9	24.0	15526	59881	45576	4.71	15662	57816	42835	3.88
Over all District (Average of all the blocks)										
Average	23.5	23.0	14618	56555	41937	3.87	15150	55252	40102	3.65
Minimum	20.6	21.2	12288	49406	36177	3.48	14513	50983	35461	3.28
Maximum	25.0	24.0	15526	59929	45576	4.71	15678	57816	42951	3.92

Table 3: Overall performance (average of two years) of wheat crop sown with super seeder under paddy residue

	Yield (q/acre)		Economics of demonstration (CRM Demo)				Economics of control/Check (Rotavator)			
	CRM Demons (Super Seeder)	Check (Rotavator)	Cost of cultivation (Rs./acre)	Gross income (Rs/ac)	Net income (Rs/ac)	B:C ratio	Cost of cultivation (Rs./ac)	Gross income (Rs./ac)	Net income (Rs/ac)	B:C ratio
Average	22.0	21.3	14739	51782	37043	3.52	15396	50379	34983	3.28
Minimum	18.0	17.4	12288	41850	27326	2.51	14513	40575	24856	2.27
Maximum	25.0	24.0	18558	59929	45576	4.71	19544	57816	42951	3.92

Conclusions

The evaluation of Super Seeder technology for wheat sowing under paddy residue in the Panipat district during 2022-2023 and 2023-2024 demonstrates its clear agronomic and economic advantages over the traditional rotavator method. The Super Seeder consistently delivered higher wheat yields, reduced cost of cultivation, increased gross and net incomes, and superior benefit-cost ratios across all blocks and years. Its adaptability was evident from its stable performance in diverse agro-ecological conditions within the district, with blocks like Ishrana and Panipat & Madlauda showing particularly strong results.

Beyond productivity and profitability, the Super Seeder's residue retention approach contributes significantly to sustainable agriculture by minimizing residue burning, enhancing soil health, conserving moisture, and supporting the microbial activity. These environmental benefits, combined with economic incentives for farmers, underscore the technology's potential for wider adoption.

Overall, the comprehensive data affirm that the Super Seeder is a cost-effective, profitable, and environmentally sustainable alternative to traditional tillage for wheat cultivation under paddy residues. Its demonstrated robustness and positive impact

on both farm economics and agro-ecosystem health make it a valuable tool for promoting the sustainable intensification of wheat production in the Panipat district.

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