

International Journal of Agriculture Extension and Social Development

Volume 9; Issue 4; April 2026; Page No. 466-470

Received: 11-02-2026
Accepted: 13-03-2026

Indexed Journal
Peer Reviewed Journal

Performance of wheat crop varieties sown with super seeder under paddy residue in district Panipat, Haryana

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DOI: <https://www.doi.org/10.33545/26180723.2026.v9.i4f.3505>

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Abstract

This study evaluated the agronomic and economic performance of various wheat varieties sown using a super seeder under paddy residue in Panipat district, Haryana, through 266 frontline demonstrations across farmers' fields during the 2024-2025 season. This study compared the super seeder technology with conventional sowing (using rotavator) across multiple administrative blocks (Bapoli, Israna, Madlauda, and Samalkha) and wheat varieties including DBW 187, DBW 222, DBW 303, DBW 327, DBW 370 & 372, HD 2967, HD 3386 & 3086, PBW 343 & 826, and WH 1270. The results revealed that the super seeder consistently outperformed conventional methods, achieving higher grain (62.6 vs. 60.8 q/ha) and straw yields (40.1 vs. 38.9 q/ha), while reducing the cost of cultivation (Rs. 42,155/ha vs. Rs. 44,801/ha). These improvements translate into increased gross and net returns and superior benefit-to-cost ratios (3.76 vs. 3.44). Varieties DBW 222 and DBW 370 and 372 exhibited the highest yields and economic returns under the super seeder system. The technology demonstrated the adaptability and reliability of super seeders across diverse agro-ecological zones and management practices within the district, supporting its scalability for sustainable wheat production and enhanced farmer livelihoods in rice-wheat cropping systems.

Keywords: Super seeder, Wheat varieties, Grain yield, Economic evaluation, Rice-wheat cropping system

Introduction

Wheat is a staple crop of critical significance in the Indo-Gangetic Plains, serving as a foundational element for food security and economic sustenance of millions of smallholder and marginal farmers (Chatrath *et al.*, 2007; Paudel *et al.*, 2025; Pingali & Shah, 2024; Sekar & Pal, 2012) ^[5, 12, 13, 16]. This region, characterized by its rice-wheat cropping system, particularly in districts such as Panipat in Haryana, faces multifaceted challenges that threaten the sustainability and productivity of wheat cultivation in the region. Among these challenges, the management of paddy residue post-harvest has emerged as a pressing concern (Bhatt *et al.*, 2023; Kumar *et al.*, 2022; Singh *et al.*, 2019) ^[2, 10, 17]. Traditional residue management practices, including manual removal and open-field burning, have detrimental environmental consequences, such as air pollution, greenhouse gas emissions, and loss of soil organic matter, which collectively contribute to the degradation of soil health and long-term agricultural sustainability (Reddy & Chhabra, 2022; Sandepogu *et al.*, 2025; Yadav, 2025) ^[14, 15, 19].

In response to these challenges, conservation agriculture practices have garnered significant attention for their

potential to mitigate environmental impacts while maintaining or enhancing crop productivity levels. Zero-tillage sowing with residue retention is a pivotal component of these practices, offering benefits such as improved soil structure, moisture conservation, enhanced microbial activity, and reduced labor and input costs (Hendrik *et al.*, 2025) ^[6]. Within this context, the development and adoption of technology, such as super seeders, that enables sowing and efficient in situ residue management, is critical to advancing sustainable wheat production systems.

Super seeder technology represents a transformative advancement in mechanized wheat sowing, which is designed to directly drill wheat seeds into standing paddy residue without the need for prior tillage or residue removal. This innovation not only addresses the environmental hazards associated with residue burning but also minimizes soil disturbance, conserves soil moisture, and reduces operational costs and labor requirements (Kathpalia *et al.*, 2023; Kumar Joshi *et al.*, 2025; Sinha *et al.*, 2023) ^[8, 9, 18]. Despite these promising attributes, there remains a paucity of comprehensive field-level evaluations of the super seeder's agronomic and economic performance, particularly across diverse wheat varieties and heterogeneous agro-

ecological zones under real-world farming conditions. Such evaluations are essential to validate the adaptability, reliability, and scalability of this technology and to provide evidence-based recommendations for its integration into existing cropping systems.

This study seeks to fill this knowledge gap by conducting extensive frontline demonstrations of super seeder technology across 266 farmers' fields in Panipat district, Haryana, during the 2024-2025 wheat season. This study systematically assessed the performance of multiple wheat varieties sown using a super seeder under conditions of paddy residue, benchmarking these results against conventional sowing practices employing rotavator-based tillage. The key parameters evaluated included grain and straw yields, cost of cultivation, gross and net economic returns, and benefit-cost ratios. By analyzing these agronomic and economic indicators across various administrative blocks and wheat genotypes, this study aims to generate robust, context-specific insights into the efficacy of super seeder technology.

Materials and Methods

The study was conducted by the Krishi Vigyan Kendra, Panipat, through 266 frontline demonstrations, each covering one hectare, across 266 farmers' fields to evaluate the agronomic and economic performance of different wheat varieties sown using the super seeder under paddy residue. The wheat varieties tested included DBW 187, DBW 222, DBW 303, DBW 327, DBW 370 & 372, HD 2967, HD 3386 & 3086, PBW 343 & 826, and WH 1270. These demonstrations were carried out under the project titled "Promotion of agricultural mechanization for in-situ management of crop residue," coordinated by the ICAR-Agricultural Technology Application Research Institute Zone-II (ATARI-II), Jodhpur.

The district Panipat, Haryana, located between latitudes 29°09'50" N-30°15'15" N and longitudes 76°10'10" E-77°17'05" E in the Indo-Gangetic Plains, features a flat terrain sloping slightly from northeast to southwest. The alluvial soils range from sandy loam to clay loam, with assured irrigation from canals and tube wells. The subtropical climate brings monsoon rains from July to September, temperature extremes from 46°C in summer to occasional frost in winter, and seasonal humidity variation. The major crops include rice, wheat, and sugarcane. Soils across the blocks of the Panipat district are predominantly alkaline (pH 6.0-9.4), with electrical conductivity varying by block, organic carbon averaging 0.58%, and 74.6% classified as medium in organic carbon. Nutrient contents differed among blocks, with nitrogen ranging from 91-244 kg ha⁻¹, phosphorus 3.6-71.2 kg ha⁻¹, potassium 67-747 kg ha⁻¹, and sulfur 9-530 kg ha⁻¹. Despite the fertile conditions, the overexploitation of natural resources remains a concern (Ajay *et al.* 2026) ^[1].

Wheat grain and straw yields were recorded by harvesting the crop from a net plot area of one hectare in each demonstration. Grain yield was calculated by weighing the cleaned and dried grains and expressed in quintals per hectare (q/ha). Straw yield was recorded by weighing the dried straw residue.

The economic parameters were calculated as follows:

- The cost of cultivation included all input costs, such as

seeds, fertilizers, labor, machinery, and other operational expenses incurred per hectare.

- The gross return was calculated by multiplying the grain and straw yields by their respective market prices prevailing at the time of harvest.
- The net return was obtained by subtracting the cost of cultivation from the gross return.
- The benefit-cost (B:C) ratio was calculated as the ratio of gross return to the cost of cultivation, indicating the economic efficiency of the technology.

This methodology allowed a comprehensive evaluation of the agronomic and economic performance of super seeder technology across different wheat varieties and agro-ecological zones within the Panipat district under paddy residue conditions.

Results

The Krishi Vigyan Kendra, Panipat implemented 266 frontline demonstrations, each of one hectare, across 266 farmers' fields to evaluate the agronomic and economic performance of the super seeder technology for wheat cultivation under paddy residue conditions during the 2024-2025 season. This study systematically assessed the performance of different wheat varieties (Table 2) and various administrative blocks within the Panipat district (Table 1). Additionally, the overall district-level performance, representing the mean of all demonstrations, is presented in Table 1 to provide a comprehensive benchmark for comparison across varieties and plots.

Performance Based on Different Blocks

The analysis across the four blocks-Bapoli, Israna, Madlauda, and Samalkha-revealed that the super seeder consistently outperformed conventional sowing methods in all key parameters, including grain yield, straw yield, cost of cultivation, gross and net returns, and benefit-cost (B:C) ratio. The average grain yield across the district using the super seeder was 62.6 quintals per hectare (q/ha), surpassing the 60.8 q/ha recorded under conventional practice. This yield advantage was similarly reflected in straw yield, with the super seeder averaging 40.1 q/ha compared to 38.9 q/ha under conventional methods (Table 1). Economically, the super seeder demonstrated clear benefits by reducing the cost of cultivation to an average of Rs. 42,155 per hectare, which is notably lower than the Rs. 44,801 per hectare incurred under conventional sowing. This reduction in cost, combined with higher yields, translated into increased gross returns averaging Rs. 158,537/ha and net returns of Rs. 116,382/ha for the super seeder, compared with Rs. 153,864/ha and Rs. 109,063/ha, respectively, for conventional practice. Consequently, the B:C ratio, a critical indicator of economic efficiency, was higher at 3.76 for the super seeder, indicating a more profitable and sustainable technology adoption compared to the 3.44 ratio for conventional sowing (Table 1). Among the blocks, Israna recorded the highest grain yield under the super seeder at 63.1 q/ha, closely followed by Madlauda with 63.0 q/ha. These blocks also showed superior straw yields (40.4 and 40.3 q/ha, respectively) and economic returns, reflecting the adaptability and effectiveness of the super seeder across diverse agro-ecological zones within the district. The lowest grain yield was observed in Block Samalkha (62.2 q/ha);

however, it still maintained a significant advantage over conventional sowing in terms of yield and profitability. The minimum and maximum values within each block further demonstrate the consistency and reliability of super seeder technology across different field conditions and farmer practices (Table 1).

Performance Based on Different Wheat Varieties

When evaluating the performance across various wheat varieties (Table 2), the super seeder consistently delivered superior outcomes compared with conventional sowing. The highest grain yield was recorded for the DBW 370 and 372 varieties at 63.5 q/ha, closely followed by DBW 222 (63.2 q/ha) and DBW 327 (62.9 q/ha). The lowest grain yield among the varieties was noted for DBW 303 at 60.8 q/ha, yet even this variety showed improved performance with the super seeder relative to conventional practice. Straw yield trends mirrored grain yield, with DBW 370 and 372 achieving the highest average straw yield of 40.9 q/ha. Economically, DBW 222, DBW 370, and DBW 372 produced the highest net returns (Rs. 118,546/ha and Rs. 118,334/ha, respectively) and the most favorable B:C ratios (3.87 and 3.79, respectively) under super seeder sowing. These figures were consistently above those recorded under conventional practice, emphasizing the economic viability of combining super seeders with high-performing wheat varieties (Table 2). The cost of cultivation across varieties remained either lower or comparable under the super seeder system, contributing to enhanced profitability without compromising the yield. The minimum and maximum values reported for each variety further underscore the robustness of super seeder technology across varying field conditions and management practices (Table 2).

Overall District Performance Comparison

The aggregated data for the entire district highlighted the clear superiority of the super seeder over conventional sowing methods for wheat cultivation under paddy residue. The technology demonstrated consistent improvements in both agronomic parameters, grain and straw yields, and economic indicators, such as net returns and benefit-cost ratio. This comprehensive dataset validates the super seeder as a viable, efficient, and economically advantageous technology for wheat cultivation in residue-retained fields in the Panipat district (Table 1). The demonstrated yield advantages, coupled with reduced cultivation costs and higher profitability, suggest that the widespread adoption of the super seeder can significantly enhance wheat production sustainability and farmer livelihoods in the region. Furthermore, the identification of high-performing varieties,

such as DBW 222 and DBW 370 and 372, under super seeder conditions provides valuable insights for varietal recommendations tailored to residue-retained wheat cultivation (Table 2). This extensive evaluation across multiple blocks and varieties confirms the super seeder’s potential to improve wheat productivity and economic returns in Panipat, making it a promising technology for scaling up in similar agro-climatic zones in the future.

Discussion

The evaluation of super seeder technology for wheat cultivation under paddy residue in the Panipat district demonstrated significant agronomic and economic advantages over conventional sowing methods. Across multiple blocks and wheat varieties, the super seeder consistently achieved higher grain and straw yields, indicating its effectiveness in enhancing crop productivity under retained residue conditions. Although variable across blocks and varieties, yield improvements reflect the adaptability of the technology to diverse agro-ecological zones and genetic materials. Notably, Israna and Madlauda recorded the highest grain yields, suggesting favorable local conditions that maximize the benefits of the super seeder. The data pertaining to yield are in corroboration with findings of Kathpalia *et al.*, 2023 ^[8] and Latif *et al.*, 2024 ^[11].

Economically, the super seeder reduced the cost of cultivation while increasing gross and net returns, resulting in superior benefit-cost ratios compared to conventional practices. The data pertaining to economics of demonstrations are in corroboration with findings of Kathpalia *et al.*, 2023 ^[8], Kumar Joshi *et al.*, 2025 ^[9] and Sinha *et al.*, 2023 ^[18]. This economic efficiency highlights the technology’s potential to improve farmer profitability and enhance sustainability. The varieties DBW 222 and DBW 370 & 372 particularly stood out, combining high yield potential with favorable economic returns under super seeder sowing, which underscores the importance of varietal selection in optimizing technology benefits. The consistency of the minimum and maximum values across blocks and varieties further supports the reliability of the super seeder under varying field conditions and management practices. This robustness is crucial for farmer adoption because it reduces the risk and uncertainty associated with new technologies. The comprehensive district-level data validate the super seeder as a scalable and efficient solution for wheat cultivation in residue-retained fields, aligning with sustainable agriculture goals by integrating residue management with improved sowing methods.

Table 1: Performance of wheat crop sown with super seeder under paddy residue in different blocks of district Panipat during 2024-2025

	CRM Demonstration (Super Seeder)						Conventional Practice (Rotavator)					
	Grain yield (q/ha)	Straw yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	Grain yield (q/ha)	Straw yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Block Bapoli												
Average	62.0	39.6	41328	156979	115651	3.80	60.7	38.7	44462	153489	109027	3.46
Minimum	58.5	36.9	36670	147853	106550	3.46	57.0	35.9	40122	144035	99825	3.18
Maximum	64.1	41.1	44088	161968	124223	4.39	62.5	40.2	46875	158268	115101	3.82
Block Israna												
Average	63.1	40.4	42728	159775	117047	3.74	61.3	39.3	45078	155087	110010	3.44

Minimum	58.8	37.6	38448	148804	105966	3.45	56.8	36.4	40575	143780	98510	3.16
Maximum	65.9	43.2	44038	166776	124072	4.04	63.4	40.7	46275	160475	115843	3.77
Block Madlauda												
Average	63.0	40.3	42004	159546	117541	3.80	61.1	39.0	44687	154561	109873	3.46
Minimum	58.0	37.1	36283	146793	106349	3.47	56.3	35.8	39377	142403	98103	3.15
Maximum	66.9	43.0	44378	169284	131719	4.51	64.6	41.7	46962	163525	122688	4.00
Block Samalkha												
Average	62.2	39.7	42280	157412	115131	3.73	60.4	38.6	44887	152747	107860	3.40
Minimum	58.9	37.2	39845	148907	105593	3.40	56.3	36.0	42107	142483	97043	3.06
Maximum	65.9	42.4	43990	166870	126411	4.17	63.4	40.9	47172	160435	117686	3.79
Overall performance of district												
Average	62.6	40.1	42155	158537	116382	3.76	60.8	38.9	44801	153864	109063	3.44
Minimum	58.0	36.9	36283	146793	105593	3.40	56.3	35.8	39377	142403	97043	3.06
Maximum	66.9	43.2	44378	169284	131719	4.51	64.6	41.7	47172	163525	122688	4.00

Table 2: Performance of different wheat crop varieties sown with super seeder under paddy residue in district Panipat during 2024-2025

	CRM Demonstration (Super Seeder)						Conventional Practice (Rotavator)					
	Grain yield (q/ha)	Straw yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	Grain yield (q/ha)	Straw yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
DBW 187												
Average	61.6	39.2	42734	155755	113021	3.65	59.5	38.1	45351	150640	105289	3.32
Minimum	58.9	37.3	41643	148907	106352	3.50	56.3	36.0	44190	142483	97043	3.14
Maximum	64.1	41.2	44378	162323	120433	3.87	62.1	39.7	46962	157158	112968	3.56
DBW 222												
Average	63.2	40.4	41447	159992	118546	3.87	61.4	39.3	44310	155321	111012	3.51
Minimum	59.5	37.9	37073	150526	112829	3.63	58.2	37.1	40750	147245	104900	3.34
Maximum	65.9	42.4	43340	166766	124042	4.35	63.4	40.5	46160	160435	115913	3.84
DBW 303												
Average	60.8	38.8	42719	153777	111058	3.60	59.0	37.7	45192	149312	104120	3.30
Minimum	59.1	37.2	41668	149335	105757	3.43	56.3	36.0	44097	142483	97456	3.15
Maximum	64.1	40.4	43790	161985	119295	3.79	62.8	40.2	47065	158950	113285	3.51
DBW 327												
Average	62.9	40.2	41653	159136	117483	3.83	61.1	39.0	44335	154603	110268	3.49
Minimum	58.0	37.1	36283	146793	106194	3.43	56.3	35.8	39377	142403	98650	3.15
Maximum	66.9	42.7	43930	169284	131719	4.51	64.6	41.4	46575	163525	122688	4.00
DBW 370 & 372												
Average	63.5	40.9	42528	160862	118334	3.79	61.8	39.5	45039	156285	111247	3.47
Minimum	61.1	38.9	39703	154879	111251	3.55	59.3	36.7	42742	149588	105038	3.30
Maximum	66.1	43.0	43963	167595	124260	3.98	64.5	41.7	46542	163418	117578	3.65
HD 2967												
Average	62.7	40.1	42353	158636	116283	3.75	60.8	38.9	44983	153888	108905	3.42
Minimum	58.5	36.9	36670	147853	105593	3.40	56.8	35.9	40122	143660	97211	3.06
Maximum	65.9	43.2	44215	166776	124223	4.39	63.4	41.0	47172	160475	115843	3.82
HD 3386 & 3086												
Average	62.9	40.3	41371	159253	117883	3.85	61.2	39.0	44441	154869	110428	3.49
Minimum	60.5	38.8	39853	153348	112740	3.74	58.8	37.7	42978	148850	104953	3.35
Maximum	64.3	41.1	42740	162723	122870	4.08	62.8	40.1	45147	158910	115820	3.69
PBW 343 & 826												
Average	62.2	39.7	41308	157428	116120	3.81	60.3	38.4	44388	152580	108192	3.44
Minimum	60.3	38.3	39825	152503	112678	3.78	58.5	36.8	43290	147808	104518	3.41
Maximum	63.4	40.6	42165	160454	118289	3.83	61.5	39.4	44865	155673	110808	3.47
WH 1270												
Average	62.8	40.2	42613	159011	116398	3.73	60.9	38.9	45088	154218	109130	3.42
Minimum	59.1	37.6	41475	149481	106003	3.43	56.6	36.2	43745	143245	97883	3.13
Maximum	65.8	42.0	44038	166504	123559	3.92	63.4	40.6	46542	160435	115168	3.60

Conclusion

Frontline demonstrations conducted in the Panipat district confirmed that super seeder technology significantly enhanced wheat productivity and economic returns sown under paddy residue compared to conventional sowing (rotavator). This technology not only improves grain and straw yields but also reduces cultivation costs, resulting in higher profitability and better benefit-cost ratios. The

performance consistency across different blocks and wheat varieties, especially DBW 222 and DBW 370 and 372, highlights its adaptability and effectiveness across diverse agro-climatic conditions. These findings support the suggestion/opinion for the wider adoption and scaling of the super seeder in similar agro-ecological zones to promote sustainable wheat production and improve farmer livelihoods. Integrating this technology with high-

performing wheat varieties offers a promising pathway for optimizing residue management and enhancing overall cropping system efficiency in the region.

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