Super Seeder: A Viable Option for Resource Conservation and Productivity Enhancement of Wheat Crop in Punjab, Pakistan

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Abstract
Mechanization has become a cornerstone of agricultural advancement in the rice-wheat cropping system of the Indo-Gangetic Plain. Technologies like the Zero Tillage Drill and Happy Seeder have helped mitigate productivity losses due to delayed wheat sowing. However, persistent challenges such as stubble burning and associated smog in Punjab necessitated more integrated solutions. In response, the Agricultural Engineering Institute (AEI), NARC, under the PSDP-funded “Productivity Enhancement of Wheat Project,” introduced the Super Seeder—a technology that combines residue management and zero tillage in a single operation. To evaluate the efficacy and adoption of the Super Seeder, a field study was conducted in year 2025

involving 61 farmers across four main rice producing districts in Punjab, who received the implements under a government subsidy scheme and used to sow wheat in year 2024-25. It is found that the use of technology resulted in cost savings in land preparation by 29%, highlighting efficiency in the operations. The productivity increased by 4.34 maunds per acre (10.3%) compared to conventional methods. Gross and net incomes of the sampled farmers increased by 10.04% and 57.92% per acre, respectively. The benefit-cost ratio improved by 14.3% (with land rent) and 17.3% (without land rent). Farmers expressed strong potential for continued use of technology. They reported that the Super Seeder offers better crop stands, labor savings, and higher profitability. Most of the users learned about technology through fellow farmers, underscoring the importance of social networks in technology diffusion. High initial cost, technical complexity, and inadequate credit and extension support remain significant constraints in large scale adoption. Financial constraints and the need for technical training were identified as priority concerns.

Keywords: Super Seeder, Adoption, Rice-Wheat Zone, Wheat Crop, Punjab, Pakistan

Introduction

The rice-wheat (RW) cropping system is a backbone of food security in Pakistan, covering millions of hectares and feeding a significant portion of the population (). However, this vital system faces growing challenges such as environmental degradation, resource depletion, and stagnating yields (Alexandrite and Bruinsma, 2012; Bhatt et al., 2021). Addressing these challenges requires a strategic shift towards more sustainable and efficient land-use practices (Ahmad and Iram, 2009; Gaydon et al., 2023). Wheat, being a staple crop, plays a pivotal role in both national and global food security (Niaz, 2008). Despite its importance, wheat productivity in Pakistan lags behind global benchmarks due to factors such as inefficient management practices, low adoption of innovative technologies, and suboptimal resource use (Raun, 2015). One major constraint is the delayed planting of wheat following rice harvest, which reduces yield potential and economic returns. To overcome this, the promotion of Resource Conservation Technologies (RCTs) has become critical (Mobin-ud-Din, 2014).

Mechanization in Pakistan has largely focused on basic crop production, with wheat being relatively better mechanized than other crops such as rice, maize, and cotton (GoP, 2018). However, with increasing food demand and shrinking water and labor resources (Kirby and Ahmad, 2022), the agricultural sector requires a paradigm shift towards integrated mechanized solutions that enhance productivity while conserving resources (Rehman et al., 2016; Kumar et al., 2023). Among the suite of RCTs—such as zero tillage, laser leveling, bed planting, and mechanical transplanting for rice and the Super Seeder stands out as a next-generation innovation. It integrates stubble management and direct wheat sowing in a single pass, eliminating the need for residue burning, which is a major environmental concern in the RW system. The Super Seeder is essentially an advanced form of the Happy Seeder, capable of cutting and managing heavy rice residues while simultaneously planting wheat. Thus, both the timeliness of sowing and residue management—two major bottlenecks in the RW system are overcome (Singh et al., 2017; Shehzadi et al., 2020; Mehmood et al., 2021). By facilitating zero tillage under heavy residue conditions, the Super Seeder enhances soil health, reduces input costs, saves labor, and contributes to higher wheat yields. It represents a viable alternative to traditional practices that involve burning rice stubble, which not only damages the environment but also delays wheat planting. Furthermore, raised bed planting and mechanical transplanting of rice complement the benefits offered by technologies like the Super Seeder by improving operational efficiency and resource use (Yigezu et al., 2021; Du et al., 2022; Islam et al., 2016).

Despite demonstrated benefits, the adoption of Super Seeder and similar RCTs remains limited due to socioeconomic, technical, and institutional barriers. Several efforts have been made by the government and research organizations, including initiatives under the Public Sector Development Program (PSDP), to promote mechanized resource-saving technologies in Pakistan's RW system. Yet, a significant gap remains between research validation and widespread adoption. This study aimed to assess the adoption, impact, and constraints of the Super Seeder technology in the rice-wheat production system of Punjab. Understanding its role and performance are critical in informing policy and extension strategies aimed at sustainable intensification of this vital cropping system. Keeping all this in view, the study has been undertaken with following specific objectives: to explore the adoption and contribution of super seeder in wheat productivity and profitability in comparison to conventional practices; to study characteristics and perception of the adopters of the technology; find the constraints in the adoption and use of these interventions at the farm level; and to provide feedback to researchers for enhancing the effectiveness of this RCT and suggest policy measures to promote it.

Materials and Methods

This study is based on primary data collected from 61 farmers of the wheat crop season 2024-25. The methodological design aimed to capture both the technical and socioeconomic aspects of Super Seeder adoption in the rice-wheat zone of Punjab. A multi-step, purposively structured approach was employed to ensure the relevance and reliability of the data. In the initial phase, the research team engaged with the Project Management Unit (PMU) of the PSDP-funded project "Productivity Enhancement of Wheat" to gain a foundational understanding of the Super Seeder technology. The team consulted with agricultural engineers from the Agricultural Engineering Institute (AEI), NARC, who are responsible for the mechanization component of the project. Their insights into the machine's design, field performance, and technical specifications were instrumental in framing the study.

Next, a survey questionnaire was drafted to capture detailed information on technology use, costs, productivity, and farmer perceptions. The tool was pre-tested in the field and revised to improve clarity and relevance. As, pre-testing ensured face validity and respondent comprehension, which are essential for minimizing bias in field surveys (Babbie, 2013). A purposive sampling method was applied to target only those farmers who have had received a Super Seeder under the subsidy program. This non-probability sampling technique is appropriate in studies where the objective is to assess impacts among specific technology adopters rather than generalize to the entire population (Etikan et al., 2016). With assistance from agricultural extension officials, face-to-face interviews were conducted in four key districts of the rice-wheat zone: Gujranwala, Sheikhupura, Hafizabad, and Sialkot. This region is representative of intensive rice-wheat cropping in Punjab and hence provides a relevant context for Super Seeder adoption. The sample distribution across districts and tehsils is presented in Table 1.

Table:1 Sample distribution across districts and tehsils

Districts	Tehsil	Sample size (n)
Gujranwala	Kamoke	13
	Gujranwala	03
Hafiz Abad	Hafiz Abad	13
	Pindi Bhatian	08
Sheikhupura	Muridkey	09
	Sheikhupura	04
Sialkot	Daska	11
Total		61

Data was analyzed using SPSS-20 for descriptive and inferential statistics, while MS Excel was employed for economic analysis. The choice of SPSS is justified by its robust capabilities in handling small to medium-sized datasets and its widespread use in social science research. A paired t-test was conducted to compare wheat production parameters between fields where the Super Seeder was used and those under conventional sowing practices. Specifically, it examined differences in production costs (e.g., land preparation, sowing, irrigation, fertilizers, plant protection & labor use) and yield outcomes. The paired samples t-test, also known as the dependent samples t-test, is appropriate in this context because it compares two conditions (Super Seeder vs. Conventional Sowing) on the same units

(Wheat Farmers), accounting for natural inter-subject variability (Mishra et al., 2019; Field, 2013). To assess the economic benefits, net incomes were calculated both with and without land rent using the following formulas:

Net income excluding land rent = Gross Income – Production Cost (excluding land rent) … (1)

Net income including land rent = Gross Income – Production Cost (including land rent) … (2)

This dual estimation provides a more nuanced understanding of profitability, particularly for users and non-users of Super Seeder. The cost-benefit framework used here aligns with standard economic evaluation practices in agricultural technology assessment (Alston et al., 2010).

Results and Discussion

Super seeder has the capacity to sow one-acre wheat crop per hour. However, due to humid and foggy conditions in the morning during wheat sowing season, the machine is preferred to use after 10:00 am when sunlight results into suitable visibility and favorable conditions for rice stubble/ straw chopping by the machine. Thus, in a working day of eight hours, it is optimistic to consider that a farmer/ service provider can easily sow six acres daily in wheat sowing season. The wheat sowing season in rice-wheat cropping zone of Pakistan last six weeks i.e. from start of November to mid of December. By considering service providers limitations to operate throughout the sowing season, working/ service days of a machine are considered 30 days per season. Keeping this information in view, estimated adoption of the technology in last five years is presented in Table 2.

Table 2. Estimated Adoption of Super Seeder in Punjab through Research/Development and PSDP Productivity Enhancement of Rice

Rabi Season/ Year	**Adoption** (No. of the Implements)	**Area coverage per day** (by the available implements)	**Area coverage per season** (000)
2020-21	25	150	4.5
2021-22	300	1800	54
2022-23	700	6300	189
2023-24	1000	60000	1800
2024-25	2000	120000	3600

Economic analysis shows Super Seeder reduces land preparation and sowing costs by twenty-nine percent i.e. Rs. 4,387 per acre ($p < 0.001$) and improves yield significantly (Table 3). Though savings in other cost components (e.g., irrigation, seed, labor) were marginal, the overall efficiency gains are evident. The findings of this study align with existing literature emphasizing the benefits of mechanized conservation agriculture practices in rice-wheat system. The statistically significant increase in yield using Super Seeder technology confirms its agronomic advantages, as also reported by Singh et al. (2018) and Gorain et al. (2025), who found consistent improvements in wheat yield when using zero-tillage machinery under rice stubble.

Table 3. Itemized cost and yield comparison of Super Seeder with conventional sowing method (n=61)

	Super Seeder	Conven-tional	Mean Difference	Change (%)	Standard deviation	t value	Sig.
	PKR/acre						
Land Preparation And Sowing Cost	10619.67	15007.38	-4387.70	-29.24	594.14	-7.38	0.000
Seed Cost	4611.07	4703.69	-92.62	-1.97	33.79	-2.74	0.008
Irrigation Cost	6649.78	6912.12	-262.35	-3.80	178.07	-1.47	0.146
Nutrients Cost	27841.33	27456.08	385.25	1.40	338.09	1.14	0.259
Plant Protection Cost	5269.67	5356.56	-86.89	-1.62	113.19	-0.77	0.446
Labour Cost	2535.35	2558.50	-23.16	-0.91	31.32	-0.74	0.463
Harvesting Cost	5639.34	5647.54	-8.20	-0.15	8.20	-1.00	0.321
Yield (Mds.)	46.53	42.19	4.34	10.29	0.47	9.28	0.000

Economic benefits attained using Super Seeder are elaborated in Table 4. Gross income increased by ten percent (Rs. 9,864) and gross margin by fifty-eight percent (Rs. 14,432 per acre), respectively. The benefit-cost ratio (BCR) improved by 14.3 percent including land rent, and 17.3 percent without land rent comparing to conventional practice, highlighting Super Seeder's financial viability even in high-cost environments. Cost reductions, especially in land preparation and sowing, further validate earlier studies by Page et al. (2020) and Kumar et al. (2021), which showed that resource-conserving technologies (RCTs) significantly reduce operational costs while maintaining or enhancing yield levels. The improved benefit-cost ratio under Super Seeder use (Table 4) mirrors findings by Du et al. (2022), indicating the technology's viability even in high-rent or input-intensive farming conditions of rice-wheat system in China.

Table 4. Benefits comparison of Super Seeder with conventional sowing method (n=61)

	Super Seeder	Conventional	Mean Difference	Percent Change
	PKR			
Mark up on production cost, Marketing cost and land tax	5560.64	5653.69	-93.05	-1.65
Land Rent (for six months)	49250.00	49250.00	0.00	0.00
Production Cost	68726.85	73295.57	-4568.72	-6.23
Production Cost with land rent	117976.85	122545.57	-4568.72	-3.73
Wheat Grain value @ Rs 2222/ 40 Kg	103404.29	93758.81	9645.48	10.29
Drystalk value	4671.42	4452.97	218.44	4.91
Production Cost per 40 kg with land rent	2535.57	2904.71	-369.14	-12.71
Production Cost per 40 kg without land rent	1477.09	1737.33	-260.25	-14.98
Gross Income	108075.71	98211.78	9863.92	10.04
Gross Margin	39348.86	24916.22	14432.64	57.92
Net income	-9901.14	-24333.78	14432.64	-59.31
BC Ratio including Land Rent	0.92	0.80	0.11	14.31
BC Ratio without Land Rent	1.57	1.34	0.23	17.36

Findings based on the field survey data revealed that farmers in middle age group with secondary school level education and ample experience adopt the technology (Table 5-I). Adopters of the Super Seeder have medium to large land ownerships with a mean holding of 22.42 acre, and operational area of 35.71 with substantial rented in land. Out of the sampled farmers, three-fourth used Super Seeder for the first time in year 2024, twenty percent in year 2023 and five percent in year 2022. Adoption of the technology happened mainly through peer influence (54%), followed by agriculture extension department (20%), family members (15%) and others sources (social media, research stations and input dealers). In reference to access to infrastructure and institutes (Table 5-II), farmers are located within reasonable distances from roads, markets and institions (less than 10 km), though research stations are farther away (19 km). In the same way, proximity to metaled road, banks, input/ output markets, agricultural extension offices, and research stations encourage the adoption. This may hinder direct exposure to innovations and highlights the importance of dedicated extension services.

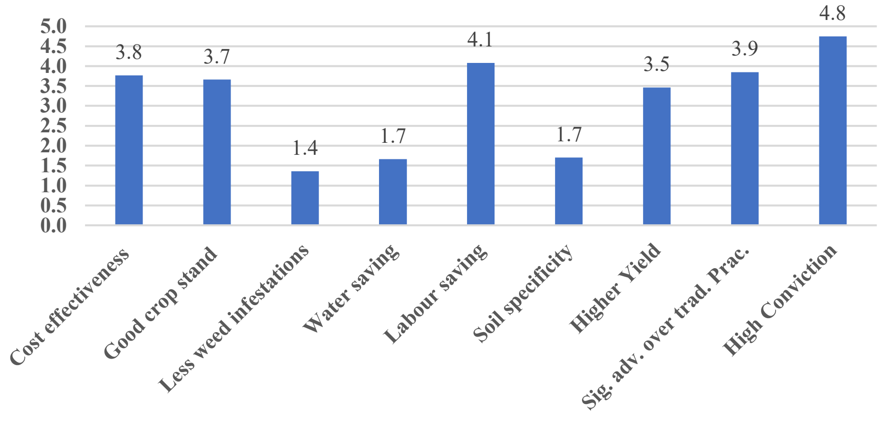
Table 5. Characteristics of the Adopters of the Technology (n=61)

	Mean	Minimum	Maximum
I. Characteristics			

Respondent Age (years)	46.80 ± 12.05	23.00	76.00
Education (Years)	10.47 ± 2.68	0.00	16.00
Farm Experience (Years)	26.10 ± 12.73	2.00	60.00
Own Land (Acres)	22.42 ± 23.94	2.00	145.00
Operational Land (Acres)	35.71 ± 33.70	0.00	150.00
II. Proximity to Infrastructure and Institutions			
Metaled roads	0.44 ± 0.71	0.00	3.50
Banks	6.83 ± 4.38	0.00	15.00
Input markets	7.45 ± 4.63	0.00	22.00
Output markets	8.67 ± 5.93	0.00	35.00
Agri. Extension	9.04 ± 4.80	0.50	25.00
Research Station	19.03 ± 7.38	7.00	40.00

Users of the Super Seeder are very optimistic, as 82% of the sampled farmers foresee increased use of the technology, 11% are neutral and 4% foretell less possibility of further spread of it. They strongly agree on its cost-effectiveness, good crop stand, labor savings and yield improvement traits (Figure 1). They believe that it has significant advantages over traditional practice and are highly convinced to up-scale its adoption. These results are in line with Yigezu et al. (2021A), who observed higher labor efficiency and improved plant establishment in mechanized sowing systems. However, skepticism prevails about water-saving, weed suppression, and site-specific soil suitability—where more research and farmers' awareness are needed. However, relatively low conviction on the water saving and weed suppression attributes suggests a knowledge gap, which can be bridged through farmer training and site-specific demonstrations.

Fig. 1 Perception in Relevance to the Technology Related Aspects



Constraints in large scale adoption of technology are high machine cost, operational complexity, and financial factors, including poor financial resource base of farmers, poor access to credit facilities to buy machines and other farm inputs, and agricultural service provision (Figure 1). Similarly, extension factors, including lack of knowledge, literature, attention of mass media, technical knowledge of extension workers, and thus conviction hinder the adoption. This corroborates previous studies like Rehman et al., (2016), who emphasized the need for targeted financial support and the development of service provision models to address affordability. Limited manufacturing by only a few firms and soil specificity also inhibit adoption.

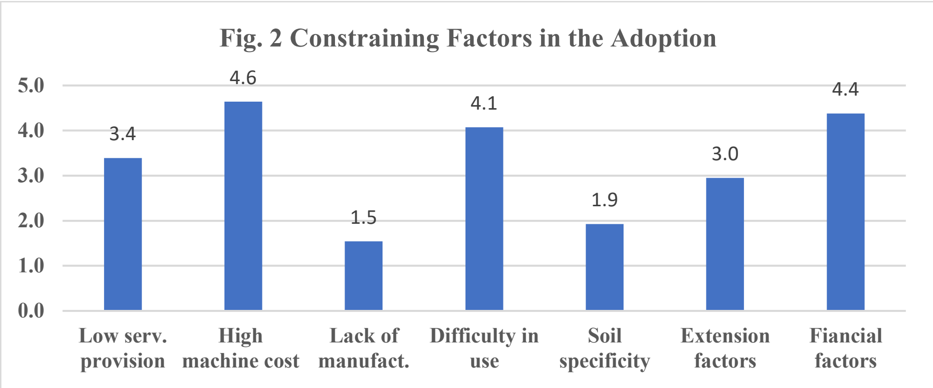


Fig. 2 Constraining Factors in the Adoption

Conclusions

The Super Seeder presents a viable solution for sustainable intensification in the rice-wheat system, addressing both environmental and economic concerns. It reduces operational costs, enhances wheat productivity, and offers a financially attractive alternative to conventional sowing practices. In addition to yield and economic benefits, the study highlighted the central role of peer-to-peer influence in promoting the adoption of Super Seeder technology. With over half of the respondents learning about technology from fellow farmers, the results emphasize the importance of social learning and local demonstration effects in accelerating technology diffusion. Moreover, while most farmers recognized the agronomic advantages of the Super Seeder—such as improved crop stand and labor efficiency—there remains a need for targeted technical training, especially to address perceived challenges around usability and site-specific performance. These insights suggest that future interventions should not only focus on subsidies and financial access, but also investment in farmer-led demonstration plots, capacity building, and strengthened collaboration between extension agents and local farmer networks to ensure sustained and inclusive adoption. However, realizing Super Seeder's full potential requires strategic support—including improved access to finance, targeted extension services, and broader awareness campaigns. With appropriate policy and institutional backing, the Super Seeder can significantly contribute to climate-smart agriculture and sustainable food production in the region. In sum, while Super Seeder adoption shows clear agronomic and economic promise, its sustained and widespread adoption will depend on policy support, affordable financing, and enhanced extension services. These findings contribute to a growing body of evidence advocating for conservation agriculture as a sustainable path for South Asian cereal systems.

Acknowledgments

PSDP Productivity Enhancement of Rice

Authors Contributions

Nadeem Akmal: Designed the study, reviewed the literature, prepared the survey tool, led the field survey, managed and analyzed the data and prepared the first draft of the article.

Abid Hussain: Assisted in preparation of the survey tool, participated in field survey, assisted in data entry and management, incorporated reviewers' comments and finalized of the article.

Muhammad Sultan: Provided technical input on the technology development aspects, assisted in preparation of the survey tool, and participated in field survey.

Khalid Mahmood: Provided technical guidance to the research team at every step of the research process.

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