Punjab's Paddy Revolution: Driving Change Through Mechanization

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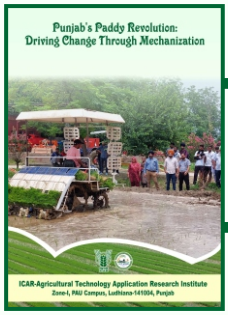

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Punjab's Paddy Revolution: Driving Change Through Mechanization

Punjab, popularly known as the rice bowl of India, has historically been crucial to the nation's food security by making substantial contributions to central rice procurement. With over 31 lakh hectares area dedicated to paddy cultivation each year, Punjab continues to be one of the foremost states in paddy production. Traditionally, the state has depended almost exclusively on manual transplanting, which, until 2018, represented more than 99% of the total paddy area. Although this method has been deeply rooted in the cultural and operational practices of the agricultural community, it has faced increasing pressure in recent years due to a mix of economic, environmental, and logistical challenges.

Punjab depends heavily on migrant labour for manual paddy transplanting during the peak periods from June to July. The skyrocketing wages, now ranging from ₹4,000 to ₹5,000 per acre, further inflates cultivation expenses, making manual transplantation financially burdensome-especially for small and marginal farmers. The traditional method relies heavily on puddling, a major contributor to groundwater depletion further intensifies Punjab's groundwater crisis nearly 76% of blocks are now "over exploited" (Central Ground Water Board, 2023). Many a times, these labour-related challenges often delays paddy transplantation and pushes back wheat sowing, exposing crops to terminal heat and affecting yields.

Mechanical paddy transplanting has emerged as a practical solution to address labour shortages, rising input costs, and water scarcity in Punjab's agriculture. Mechanised paddy transplanting has seen modest growth: from a mere 0.03 lakh ha (0.1%) in 2015 to 0.37 lakh ha (1.1%) by 2024 (Table 1). Farmers are increasingly adopting various types of transplanters, including self-propelled single wheel paddy transplanter (Fig.1), self-propelled walk-behind paddy transplanter (Fig.2), and self-propelled four wheel paddy transplanter (Fig.3) with four/six/eight rows. A major advantage of mechanical transplanting is its operational efficiency, which ensures uniform planting and optimal plant density, ultimately improving crop performance. These advantages are driving gradual adoption despite high upfront costs and the need for technical expertise.

Table 1. ***Area under manual and mechanical paddy transplanting in Punjab***

Year	Manual transplanting		Direct seeded rice		Mechanical transplanting		Total area (lakh ha)
	Area (lakh ha)	% of total	Area (lakh ha)	% of total	Area (lakh ha)	% of total	
2009	27.99	99.89	0.00	0.00	0.03	0.11	28.02
2010	28.23	99.89	0.00	0.00	0.03	0.11	28.26
2011	28.15	99.89	0.00	0.00	0.03	0.11	28.18
2012	28.38	99.61	0.09	0.32	0.02	0.07	28.49
2013	28.08	98.56	0.39	1.37	0.02	0.07	28.49
2014	27.77	95.92	1.15	3.97	0.03	0.10	28.95
2015	28.02	94.34	1.65	5.56	0.03	0.10	29.70
2016	30.22	99.21	0.20	0.66	0.04	0.13	30.46
2017	30.49	99.51	0.09	0.29	0.06	0.20	30.64
2018	30.52	99.61	0.06	0.20	0.06	0.20	30.64
2019	28.88	98.90	0.23	0.79	0.09	0.31	29.20
2020	23.41	80.17	5.54	18.97	0.25	0.86	29.20
2021	25.56	81.27	5.62	17.87	0.27	0.86	31.45
2022	30.65	96.78	0.69	2.18	0.33	1.04	31.67
2023	30.74	96.70	0.70	2.20	0.35	1.10	31.79
2024	31.03	95.77	1.00	3.09	0.37	1.14	32.40

Source: **Anonymous (2025a), Anonymous (2024a), Anonymous (2024b), Anonymous (2022), Lohan (2021), Anonymous (2019), Anonymous (2020a), Anonymous (2020b)**

Table 2. ***Brief technical specifications of the paddy transplanters***

Particulars	Self-propelled walk behind	Self-propelled single wheel	Self-propelled four wheel
Type of nursery used	Mat type	Mat type	Mat type
Power source	Petrol Engine, 3.20 kW	Diesel Engine, 2.94 kW	Petrol Engine, 12.5 kW
Type of steering	Handle type	Mechanical	Hydraulic
No. of gears	1 Forward, 1 Reverse	3 Forward (2 for Field & 1 for Road), No Reverse	5 Forward, 5 Reverse
Number of rows	4	8	6
Plant to plant spacing (cm)	12, 14, 18, 21	14, 17	12, 14, 16, 18, 21
No. of hills transplanted/m²	Four settings	Two settings	Five settings
Transplanting depth	Adjustable	Adjustable	Adjustable
Type of planting finger	Plate bar with notch	Needle type	Plate bar with notch
Material of tray	Plastic	Galvanized iron sheet	Plastic
Traction wheel type and material	Iron wheel with rubber lugs	Iron wheel with iron lugs	2 front non-puncture rubber wheels & 2 rear iron wheels with rubber lugs
Transport wheel type	Pneumatic	Pneumatic	Pneumatic
Float type & material	Split bars, plastic	Single piece, fibre	Split bars, plastic

Source: **Manes *et al.* 2013**

Fig. 1. Self-propelled Single Wheel Paddy Transplanter

Fig. 2. Self-propelled Walk Behind Paddy Transplanter

Fig. 3. Self-propelled Four Wheel Paddy Transplanter

Raising Mat Type Nursery for Mechanical Transplanting

For successful mechanical paddy transplantation, a mat-type nursery is essential and around 50 m² of nursery area is needed per hectare. Traditionally, mat-type nurseries are prepared manually, with two individuals able to sow enough nursery for 2 ha of paddy transplanting in a single day. However, the manual process is labour-intensive and time-consuming, involving multiple steps: preparing the seedbed, laying polythene sheets, placing frames, filling them with soil, evenly spreading pre-germinated seeds (2-3 seedlings per cm²), covering them with a thin soil layer, and sprinkling water for proper soil settling. Once done, the frames are removed and the process repeated. This method is physically demanding and slow, making it less appealing to many farmers.

Punjab Agricultural University (PAU), Ludhiana, developed a tractor-operated seeder specifically designed for sowing mat-type nurseries, significantly streamlining and accelerating the process. This innovative machine performs all essential tasks in a single pass: it cuts soil from both sides, conveys it via augers, distributes it evenly, and lays a 1.0-meter-wide perforated polythene sheet (50-60 gauge) over the soil bed. Simultaneously, it ensures uniform seed placement over the soil bed, ideal for nurseries intended for mechanical paddy transplanters.

Manual Sowing of Mat Type Nursery

Mechanical Sowing of Mat Type Nursery

The machine features a soil-cutting unit with a depth control wheel to create consistent mats. Soil is transferred to a sieving unit, where larger clumps of soil are removed, and the refined soil is deposited into a hopper. A roll of polythene sheet mounted in front of the hopper is unrolled over the bed, onto which metered seeds are placed. A thin layer of soil is then applied to cover the seeds lightly. Compatible with tractors of 40 hp or more, the machine can sow mat-type nursery for transplantation in paddy field area of 55-60 ha/day. It maintains a soil mat thickness of 24-26 mm and consumes approximately 4.5 l/h. The labour required with the machine is 0.67-0.72 man-h/ha. There is a cost saving of 61.4-64.6% and labour saving of 91.0-91.6% as compared to the conventional manual method of mat-type nursery sowing (Table 3).

Using the PAU mat-type nursery seeder reduces operational costs as compared to manual methods. It performs all nursery establishment tasks in one operation, ensuring

Table 3. ***Cost and labour saving with tractor operated mat type nursery seeder***

Parameter	Mat-type nursery with tractor operated machine	Mat-type nursery with manual method
Cost of operation, ₹/day	10120.0	954.5 @ 2 persons
Mat-type nursery prepared for paddy field, ha/day	55-60	2
Cost of mat-type nursery preparation, ₹/ha	168.7-184.0	477.2
Saving in cost, %	61.4-64.6	-
Labour required, man-h/ha	0.67-0.72	8.0
Saving in labour, %	91.0-91.6	-

Source: ***Anonymous*** **(2025b)**

uniform seed distribution. In contrast, manual sowing is labour-intensive, time-consuming, and physically demanding. This machine offers an efficient, user-friendly, and effective solution for mat-type paddy nursery cultivation.

A Memorandum of Understanding (MoU) has also been executed with M/s Rajarh Agricultural Works, Mullanpur, Ludhiana, for the commercialization of PAU's innovative mat-type nursery seeder. To date, 28 units have been successfully sold. This partnership has become a model for advancing mechanized mat-type nursery systems, significantly improving the efficiency of mechanical paddy transplanting in Punjab and elsewhere. The cost of mat type nursery seeder is approximately Rs. 3.5 lakh, and the government is also offering a 40% subsidy to farmers for the purchase of this machine.

A total of 30 validation trials in participatory mode focusing on the mechanical transplantation of paddy seedlings were carried out during the *kharif* 2024 across six districts; Hoshiarpur, Sangrur, Jalandhar, Kapurthala, Ludhiana, and Ferozepur in Punjab, with each hosting five distinct locations.

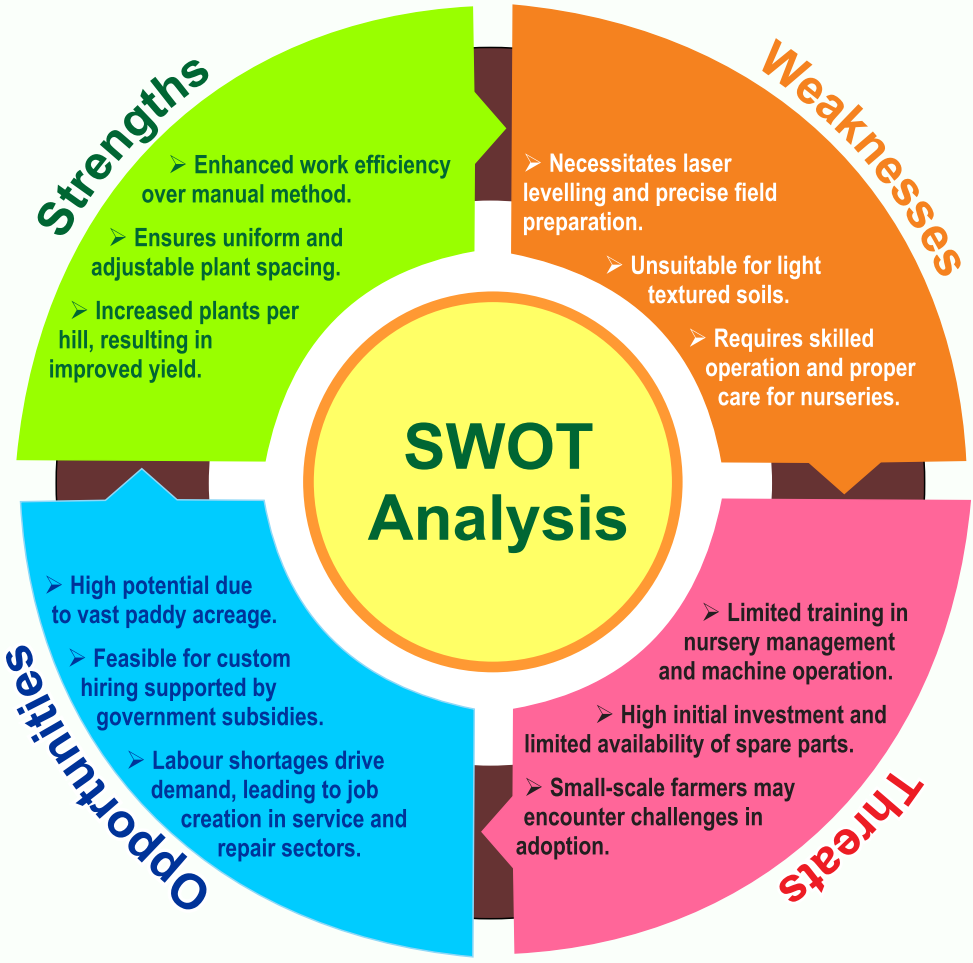
The study compared traditional farmer practices (manual transplanting) with three treatments using mechanical transplanters. In the conventional method, sprouted

Table 4. ***Performance evaluation of manual vs mechanical transplanting in paddy***

Particulars	Self-propelled walk behind paddy transplanter	Self- propelled single wheel paddy transplanter	Self-propelled 4 wheel paddy transplanter	Farmer's Practice (manual transplanting)
Row to row spacing (cm)	30	30	30	-
Plant to plant spacing (cm)	14	14	14	-
Hills (No./m^2) at transplanting	23.20^a	22.18^b	22.92^a	16^c
Missing hills (%)	2.56^b	10.24^a	3.74^b	-
Mortality (%)	3.43^b	10.75^a	3.70^b	-
Field capacity (ha/day)	0.8-1.2 (1.0^b)	1.12-1.3 (1.2^b)	2.5-3.0 (2.92^a)	-
Plant stand (No./m^2) 15 DAT	23	19	23	16
Panicles (No./m^2)	319.3^a	279.7^b	319.9^a	275.9^c
Grain yield (q/ha)	75.93^b	74.81^c	76.82^a	73.91^d
Cost of production (Rs/ha)	57715	57470	56520	64423
Gross returns (Rs/ha)	174639	172063	176686	169993
Net returns (Rs/ha)	116924	114593	120166	105571
B:C ratio	3.03	2.99	3.13	2.64

seeds of paddy variety PR 126 were broadcasted, and 30-day-old seedlings were manually transplanted. In contrast, mechanical methods used mat-type nurseries with 25-day-old seedlings transplanted mechanically. The crop was managed as per the standard package of practices (Anonymous, 2024c).

Comparative performance of different transplanting techniques revealed that machine-based transplanting methods performed well and offered better efficiency and returns as compared to traditional manual transplanting.



SWOT Analysis of Mechanical Paddy Transplantation

FARMER'S VOICE

S. Gurdeep Singh

S. Gurdeep Singh, a resident of the village Kot Fatuhi in Mahilpur block of Hoshiarpur district, oversees a 100-acre agricultural farm. In an effort to modernize his farming techniques, he acquired a four-wheel self-propelled paddy transplanter during *kharif* 2023. He utilized this machine to mechanically transplant paddy across 70 acres of his own fields and also offered this service to neighboring farmers on a hiring basis for an additional 50 acres. By 2024, S. Gurdeep Singh had facilitated mechanical transplantation of paddy over a total of 200 acres. He strongly advocates for the importance of maintaining a uniform density of paddy nursery mats to ensure effective mechanical transplantation. It is essential that pre-germinated paddy seeds in mats are distributed evenly. This mechanized method delivers a higher number of uniformly spaced plants compared to manual transplanting, ultimately boosting crop yields.

S.Sukhdev Singh

Recognizing the necessity for mechanization in paddy farming, S. Sukhdev Singh from Village Chak Malan, Block Mahilpur, district Hoshiarpur, made a calculated choice to purchase a paddy transplanter. In 2024, he effectively transplanted 225 acres using a four-wheel self-propelled paddy transplanter, which included 30 acres of his personal land. He explicitly emphasized the reliance of machine efficiency on the proper preparation of mat type nursery.

S. Jaswinder Singh

In light of the typical labor shortages encountered during the peak seasons of paddy transplantation, the Lambra Kangri Multi-Purpose Cooperative Service Society Limited, located in the village of Lambra within the Hoshiarpur district, has acquired a 6-row self-propelled paddy transplanter. This initiative allows them to provide cost-effective rental services for the mechanical transplantation of paddy over an area of 200 acres annually within the district. Insights from Mr. Jaswinder Singh, the Project Manager of the Society, indicate that this mechanization has resulted in significant time savings, enhanced flexibility in adjusting the spacing between plants, and greater ease in the application of agricultural inputs when compared to traditional manual transplantation.

WAY FORWARD

The effort to scale mechanical transplanting in Punjab-while promising-has encountered notable challenges. High capital costs (even with substantial government subsidies) remain unaffordable for most small and marginal farmers. Successful machine use hinges on precise land leveling and mat type nursery raising, both of which require technical acumen. In reality, rugged terrain and heavy, clayey soils impair machine efficiency, and operators often lack the necessary skills. This combination of high upfront costs, technical complexity, and challenging field conditions has significantly constrained adoption despite strong policy support.

1. Expand Custom Hiring Centres (CHCs)

- Deploy CHCs at block level to ensure all farmers, especially smallholders, have nearby access to machines.
- Strengthen logistics to avoid delays and build trust.
- Bundle CHCs with trained operators to safeguard timely service.

2. Leverage Digital Tools & Transparency

- Develop a 'Paddy Mechanization App', for real-time reservations, machine/operator tracking, and technical help.
- Integrate transparent pricing, usage tracking, operator ratings, and support features to improve adoption.

3. Enhance Financial Support

- Tie-up with FPOs, cooperatives, rural banks to provide low-interest loans or lease-to-own models.
- Promote group ownership and shared cost models via CHCs/FPOs with substantial capital supports.

4. R&D & Equipment Customization

- Encourage SAUs and ICAR to develop lightweight, terrain adaptable and cost effective transplanters.
- Focus on models suited to small plots, increasing inclusivity for smallholders.

5. Skill Building & Capacity Enhancement

- Scale up capacity building via KVKs and ATARIs: practical workshops, nursery/mat-type demonstrations, and field training, etc.
- Establish a certified "operator training" program to standardize proficiency and support CHCs.

Mechanical transplanting has graduated from a pilot initiative to a scalable, transformative, and climate resilient approach in Punjab's paddy cultivation. It effectively addresses labour shortages, ensures timely and uniform crop establishment, and significantly reduces water usage-both essential for a region grappling with depleting groundwater reserves. The futuristic roadmap to mainstream mechanical transplanting across 10-15% of its paddy area by 2030 requires a multi-pronged strategic, inclusive, and technology-driven approach. By aligning technological advancements with grassroots training and solid institutional support, Punjab is well positioned to lead India in sustainable mechanization of paddy-turning potential into enduring agricultural progress.

POLICY, INNOVATION & FARMER EMPOWERMENT

Policymakers → Why these matters?

- Enhance the efficiency and targeting of subsidies by leveraging data driven delivery systems (e.g. geotargeting, direct benefit transfers), while promoting digital platforms that connect Custom Hiring Centres (CHCs) with smallholder farmers and ensure timely access to mechanization.
- Implement policies that support group ownership models (e.g. Farmer Producer Organizations, Self Help Groups, local cooperatives) and entrepreneurial ventures in rural areas-as a path to strengthen inclusive rural mechanization.

Research Institutions → Why their role is crucial?

- Prioritize participatory, field based co design approaches: conduct on farm trials, gather structured farmer feedback (usability, durability, and ergonomics), and iteratively refine mechanization tools in collaboration with users.
- Facilitate formal partnerships between academia, government agencies, and agri-industry stakeholders to align research outcomes with ground realities and drive scalable mechanization innovations.

Farmers → Why their engagement drives success?

- View mechanization not just as a cost-saving measure, but as a strategic capital investment to enhance operational efficiency, yield, and long term profitability and sustainability.
- Actively participate in training programs and embrace cooperative models to share machinery, gain skills, and help build locally owned, inclusive value chains.

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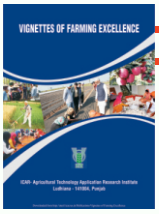

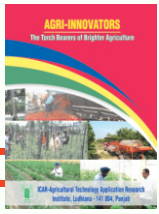

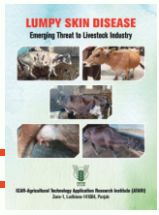

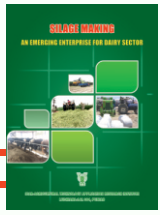

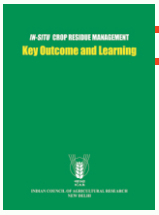

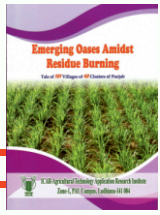

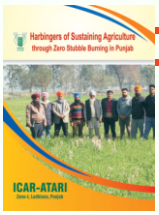

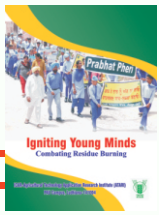

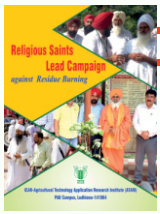

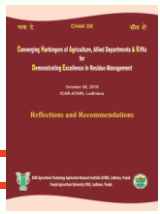

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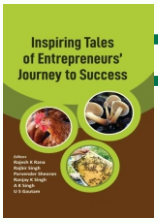

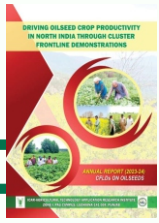

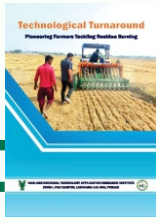

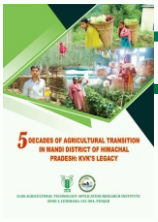

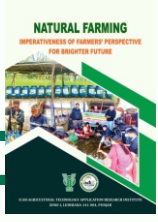

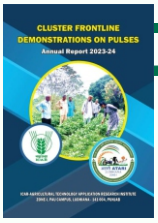

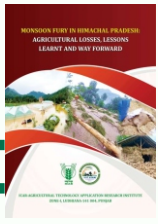

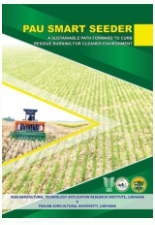

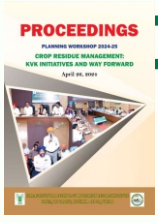

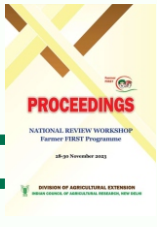

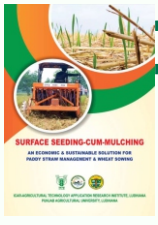

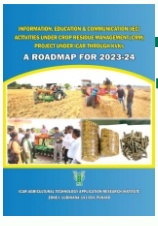

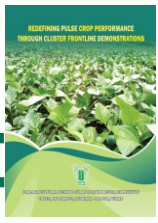

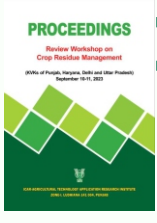

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