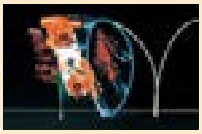
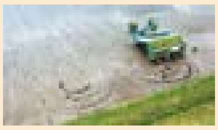
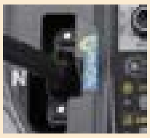
Evolution and History of Environmentally Friendly Products and Services

Evolution and History of Rice Transplanters

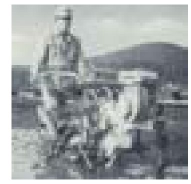
The Kubota Group developed the world's first walk-behind rice transplanter using seedling mats in 1968 with the aim of reducing the burden of planting rice. In order to meet demand for labor-saving measures precipitated by the subsequent decline in the number of farmers and the aging of Japan's population, we continued to develop our lineup of rice transplanters—we made them rideable, bigger, and equipped them with more functions. We will continue to implement labor-saving efforts and reduce our impact on the environment by proposing efficient cultivation methods and refining agricultural practices with the use of ICT and automation.


Seedling mats grown in trays

■ Historical Development and Environmental Contributions of Rice Transplanters

Decade	Social trends in Japan	Progress in rice transplanter development	Environmental contributions
1950s	· High economic growth · Shift in labor from rural areas to cities	· Start of development	**Increasingly lighter walk-behind rice transplanters**
1960s	· The mechanization of rice transplanting lagged behind the emergence of tractors and binders · Increase in part-time farmers, the elderly, and women engaged in agriculture	· **Development and sales launch of SP model (2-row) walk-behind rice transplanter** (1968)	
1970s	· Shift from "walk-behind" to "ride-on" agricultural machinery · Boom in agricultural machinery · Convergence of high economic growth · Occurrence of so-called "red tide" at Lake Biwa (1977)	· **Sales launch of SPS model (2-row) walk-behind rice transplanter** (1970) · Start of volume production of SPS series (sales: 18,000 units in first year; 86,000 in second year) · **Sales launch of SPR600 model (6-row; tractor-driven), Kubota's first ride-on rice transplanter** (1976)	**Increasingly larger ride-on rice transplanters and lower weight-to-power ratio** **Expanding capabilities of ride-on rice transplanters to simultaneously perform other tasks**
1980s	· Growing need to reduce burden of agricultural work [Rotary system] Adoption of rotational planting mechanism improved work speed by 50% and boosted efficiency  Miracle Rotary developed in 1991	· **Sales launch of NSR series of ride-on rice transplanters with row-side fertilizer applicator to reduce amount of applied fertilizer and prevent water contamination** (1980) **Pesticide spraying and other simultaneous features also subsequently developed** · **Sales launch of NSR85-D model (8-row) specialized ride-on rice transplanter** (1984) · Sales launch of S1-600R model (6-row) rotary-type ride-on rice transplanter (1988)	
1990s		· Continued development of compact, lightweight rice transplanters, as well as larger ride-on rice transplanters · **Sales launch of SPM10 model (10-row) large ride-on rice transplanter** (1995)	
2000s	[Easy turning] Ability to complete smooth turns with only the steering wheel [Easy speed shifting] Prevents sudden acceleration and allows for smooth starts at ultra-low speed  World series performing smooth turns	· Sales launch of Welstar series of ride-on rice transplanters equipped with new easy turning and easy speed shifting capabilities to improve operability (2000) · **Sales launch of NSD8 model (8-row) ride-on rice transplanter capable of efficiently performing five functions simultaneously** (2007) · **Sparse planting proposal** (2009)	**Proposing efficient cultivation methods**
2010s	· Increasingly higher concentration of farmland among large-scale farmers · Skyrocketing fuel prices · Emergence of high-precision farming using ICT · Shift to driverless farm machinery [e-stop] Easy use of a lever to stop the engine when restocking seedlings or fertilizer reduces fuel consumption by around 12%* 	· **Sales launch of direct seeder for iron-coated rice seeds "Tetsumaki-chan"** (2010) · Sales launch of Racwel, the industry's first ride-on rice transplanters equipped with idling stop feature "e-stop" (2011) · **Sales launch of EP8D-GS model (8-row) ride-on rice transplanter equipped with industry-first straight-line keeping feature** (2016) · **Demonstration of dense seedling transplanting** (since 2017) · **Sales launch of NAVIWEL series of ride-on rice transplanters capable of maintaining planting distance, controlling amount of applied fertilizer, and keeping straight lines** (2019)	**Eliminating inefficiencies with precision farming**
2020		· **Sales launch of Agri Robo Rice Transplanter NW8SA, the industry's first self-driving rice transplanter**	

* Comparison of fuel consumption when planting rice seedlings under the following conditions (Kubota's estimates; fuel consumption may differ depending on the conditions): Rice transplanter capacity of 8 rows, area of 0.5ha, 20 seedling mats per 0.1ha, 40kg of fertilizer per 0.1ha, one transplanter operator, and one assistant



SP model—Kubota's first walk-behind rice transplanter

Increasingly Lighter Walk-behind Rice Transplanters

Even though the walk-behind rice transplanter first developed in 1968 increased in mass due to the addition of extra features through the 1980s, we made each model lighter and more streamlined mainly with the use of an aluminum gearbox housing and a plastic float. This meant we were able to conserve resources and make operations much more efficient.

<Changes in Weight and Horsepower of 2-row Walk-behind Rice Transplanters>

Launched	1968	1970	1981	1987	1990	2003
Model	SP	SPS-2	NS300-D	S1-25	S1-20	SP-2
Weight (kg)	**100** Weight reduction	**60** Added features	80	**108** Weight reduction	**91**	**88**
Horsepower (PS)	3.0	1.7	1.4	2.1	2.3	2.3
Weight (kg) / Horsepower (PS) [vs. NS300-D]	33.3	35.3	**57.1**	**51.4 [-10%]**	**39.6 [-31%]**	**38.3 [-33%]**

Increasingly Larger Ride-on Rice Transplanters and Lower Weight-to-power Ratio

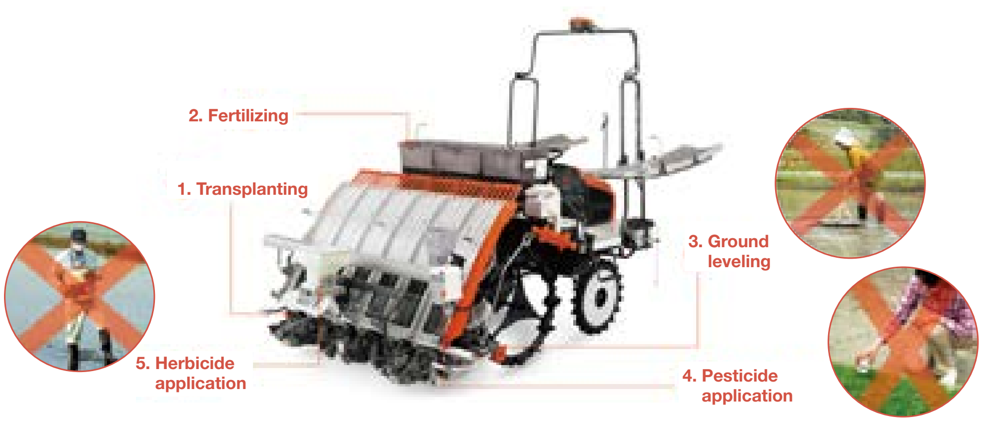
The ride-on rice transplanter that first went on sale in 1976 gradually increased in size so it could plant more rows at the same time, thus boosting work efficiency. However, the heavier it became, the deeper it sank into the mud, which easily hindered its running performance. We therefore strived to provide more horsepower when making the machine larger, but at the same time we took steps to make it lighter. By reducing its weight-to-power ratio (mass divided by horsepower), we were able to conserve resources and achieve higher operating efficiency.

<Changes in Size, Weight, Horsepower, and Planting Capacity of Ride-on Rice Transplanters>

Launched	1976	1984	1995	2014	2019
Model	SPR600 (Kubota's first ride-on model; tractor-driven)	NSR85-D (first specialized rice transplanter)	SPM10 (first 10-row transplanter)	EP10D	NW8S-GS
No. of rows	**6** Size increase	**8** Size increase	**10**	10	8
Weight (kg)	530	490	978	970	960
Horsepower (PS)	9	6.2	16.0	21.0	24.6
Weight (kg) / Horsepower (PS) [vs. NSR85-D]	58.9	**79.0**	**61.1 [-23%]** Lower weight-to-power ratio	**46.2 [-42%]**	**39.0 [-51%]**
Time (min) required to plant 0.1ha	**25–30** Higher work efficiency	**15–20**	**7–**	7–	7–

Expanding Capabilities of Ride-on Rice Transplanters to Simultaneously Perform Other Tasks

In the past, fertilizer was applied uniformly over the rice paddy after the seedlings were planted, but surface runoff from excessive application was one reason behind the occurrence of a so-called "red tide" at Lake Biwa in Shiga Prefecture in 1977. Kubota therefore developed a row-side fertilizer applicator to bury the right amount of fertilizer at the root of each seedling when it is transplanted. Not only did this prevent fertilizer runoff from overapplication, but the simultaneous application of fertilizer considerably reduced the amount of labor required and saved costs because less fertilizer was used. We took the idea of multi-tasking even further by developing a product in 2007 that can perform five jobs at once: transplanting, fertilizer application, herbicide application, pesticide application, and ground leveling. This equipment significantly reduced labor and made work more efficient.



Five functions in a single rice transplanter

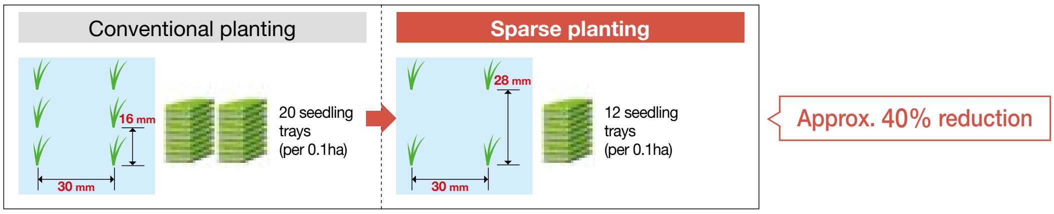
Proposing Efficient Cultivation Methods

The hours spent raising and transplanting seedlings account for approximately 30% of all wet-rice farming work. The Kubota Group proposes cultivation methods that can reduce the number of seedling trays used or even eliminate the very need to raise seedlings in order to reduce manpower, time, and costs involved in raising and transplanting seedlings.

Limiting the volume of seedlings raised, the number of seedling trays, and even the seedlings greenhouse reduces the resources introduced into the environment and also curtails the amount of energy required to maintain and manage a seedlings greenhouse.

<Rice Cultivation Methods Proposed by the Kubota Group>

Method	Details
Sparse planting (since 2009)	This cultivation method employs a lower planting density by spreading out the clumps of seedlings. Reducing the density means fewer seedlings are required, thus reducing the number of seedling trays by around 40–50%. While this method results in somewhat fewer ears of rice, the volume per ear is higher, therefore the volume of unhulled rice per unit area is roughly the same as, or only slightly lower than, conventional planting.



Method	Details
Direct sowing with iron-coated seeds (since 2010)	This method involves the dispersal of seeds coated with iron powder across the surface of the rice paddy. Unlike transplanting, the raising of seedlings is not required. If Kubota's direct seeder for iron-coated seeds is used, high-speed sowing at intervals, fertilizing, herbicide application, and grooving can be performed simultaneously to sharply reduce work time and conserve energy.

6-row direct seeder for iron-coated seeds (WELSTAR WORLD WP60D-TC)

	Transplanting	Direct seeding with iron-coated seeds	
	16–20 seedling trays (per 0.1ha)	None	Not required
Space/greenhouse for seedling trays (per 0.1ha)	Around 6.6m^2	None	Not required
Raw material costs (per 0.1ha)	19,200 yen	14,300 yen	Approx. 26% reduction
Time required to raise seedlings and transplant/sow (per 0.1ha)	5.38 hours	1.51 hours	Approx. 72% reduction

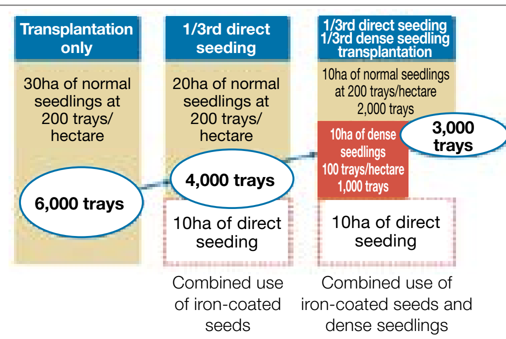
* 2015 National Workshop on Agricultural Systemization (Yamagata)

Method	Details
Dense seedling transplantation (since 2017)	This cultivation technique involves the use of seedlings raised more densely than usual in a single tray. The seedlings are then planted in small amounts with a rice transplanter. The dense seedling transplantation method can halve the number of seedling trays compared to when using young seedlings grown the conventional way. Almost all Kubota rice transplanters are capable of transplanting dense seedlings.

	Conventional 140–180g of dry seeds per tray	Dense seedlings 230–250g of dry seeds per tray	
	Density of seed rice; 16–20 seedling trays (per 0.1ha)	Density of seed rice; 9–12 seedling trays (per 0.1ha)	Considerable reduction
Space/greenhouse for seedling trays (per 0.1ha)	Around 6.6m^2	Around 3.3m^2	Considerable reduction
Seedling material costs* (per 0.1ha)	19,200 yen	15,900 yen	Approx. 20% reduction
Labor (per 0.1ha)	1.25 hours	0.86 hours	Approx. 30% reduction

* Results differ in each region. Please refer to region-specific information for more details. Source: 2017 National Workshop on Agricultural Systemization.

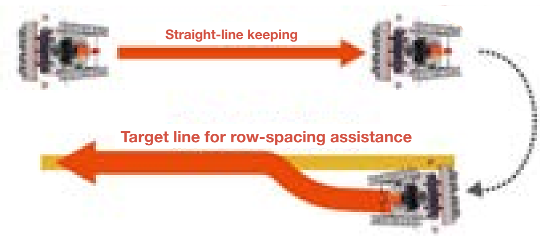
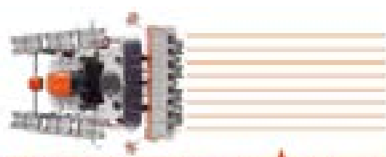
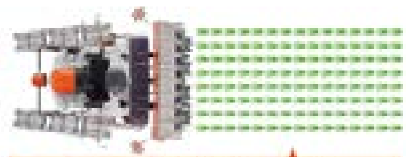
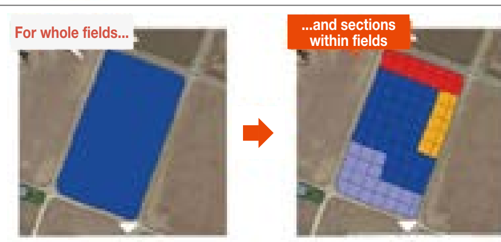
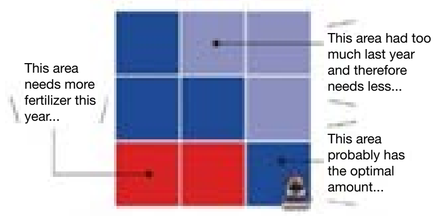
Method	Details
Combination of direct sowing with iron-coated seed and dense seedling transplanting	The Kubota Group proposes that the combination of direct seeding with iron-coated seeds and the high dense seedling transplantation can reduce seedling trays, spread out the harvesting season, and expand scale. Directly seeding iron-coated seeds, which significantly cuts down on labor, and transplanting a certain percentage of high dense seedlings, can reduce the number of seedling trays required.



Eliminating Work Inefficiencies with Precision Farming and Helping Reduce Environmental Impacts

In Japan, more and more agricultural land is being managed by large-scale farming households, so it is vital that we develop high-performance, high-precision products to meet the needs of farmers to boost revenue and cut costs. In 2016, the Kubota Group outpaced its rivals in bringing to market a rice transplanter capable of maintaining straight planting rows. Ever since, we have continued to develop numerous functions to achieve high-precision rice transplanting. These features enable even the inexperienced to easily plant rice seedlings with great accuracy, while for seasoned farmers, they help improve work efficiency by alleviating fatigue.

<GPS-based ICT Functionality>

Function	Details	Environmental contributions
Straight-line keeping (GS) and row-spacing assistance	The straight-line keeping function uses GPS to self-steer when proceeding straight ahead so that even beginners can easily transplant seedlings in straight rows. When used in combination with the row-spacing assistance function, any deviations in distance between adjacent rows can be corrected.   Self-steering when checking the transplantation of seedlings	Planting seedlings in straight rows can help reduce the wasteful consumption of fuel and materials (seedlings, fertilizer, pesticide, etc.).
Spacing control and fertilizer application control	Owing to the fact that rice transplanters slog through the mud in rice paddies, the spacing between seedlings planted with the conventional wheel-linked mechanism can vary depending on the degree of slippage. Kubota's spacing control and fertilizer volume control functions use actual GPS-based speed data to accurately gauge distance travelled and correspondingly control the rotational speed of the planting claws and fertilizer rollers. This allows seedling transplantation and fertilizing to be carried out according to a preset distance between seedling clumps.  Fertilizer application control enables uniform application of preset fertilizer volume.  Spacing control maintains preset seedling distance.	Farmers usually prepare 10% more seedlings and fertilizer than planned to compensate for errors caused by rice transplanter slippage. Kubota's spacing control and fertilizer application control functions can reduce these extras, thereby minimizing the materials and energy required to prepare seedlings and curtailing the amount of fertilizer resources actually used.
Adjustable fertilizing (NW8S-PF-GS)	KSAS* can be used to create fertilization maps of rice paddies that visualize where and how much fertilizer is needed. Rice transplanters equipped with adjustable fertilizing functionality can apply optimal amounts of fertilizer by syncing with this map data. * KSAS stands for Kubota Smart Agri System, our ICT-powered agricultural management support service.   Mesh maps for fields can be created and fertilizer application rates assigned to each mesh (5m, 10, 15m, or 20m). * Settings must be entered manually.	The optimization of fertilizer application rates minimizes unevenness in rice growth and delivers increased stability in terms of eating quality and yields. In turn, this reduces inputs per yield.

Furthermore, in 2020 we launched the self-driving Agri Robo Rice Transplanter NW8SA. Transplanting work is carried out by two people: one operator and one assistant to restock the seedling trays. However, the rice transplanter drives itself, thus reducing manpower and improving work efficiency. Stable cultivation is achieved because the machine plants the seedlings with minimum overlapping. It also curbs wasteful consumption of fuel and resources by automatically plotting the most economical route.

Agri Robo Rice Transplanter NW8SA