Research article

Recent Expansion and Future Perspectives of Direct Rice Seeding in Miyagi Prefecture of Japan

HIROEI KANNO
Graduate School of Agricultural Science, Tohoku University, Sendai, Japan
Organization Miyagi Prefectural Furukawa Agricultural Experiment Station, Osaki, Japan

KOKI HOMMA*
Graduate School of Agricultural Science, Tohoku University, Sendai, Japan
Email: koki.homma.d6@tohoku.ac.jp

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Abstract In Asia, the most common method of planting rice is transplanting seedlings, but there is a gradual and progressive shift to direct seeding. In Japan, recent socioeconomic factors and the population trends of aging and migration to urban centers, have led to a decrease in labor which has forced many rice farmers to utilize direct rice seeding in their fields so that they can manage larger fields with less labor. We investigated the expansion of direct seeding in Miyagi Prefecture in the Tohoku region of Japan and discussed the technology that led farmers to accept the direct seeding methods. An early and critical turning point was the Great East Japan Earthquake of 2011, which required the reconstruction of paddy fields and farmers' associations after the earthquake and the resultant highly destructive tsunami. The direct seeding area in Miyagi Prefecture occupied 1.5% of the rice planting area in 2011 just before the earthquake. The direct seeding area increased to 6.9% as of 2023. The wet seeding method of direct seeding was applied during the initial expansion stage because thermal retention by flood waters was necessary. However, one of the major constraints of wet seeding is low germination, which has led to the technological development of enhanced seeding methods. In particular, coatings applied to the seeds and specifically the iron coating used in wet seeding contributed to the initial expansion of direct seeding. The more recent expansion of direct seeding is being driven by the dry seeding method. Dry seeding in early spring was established to obtain relatively stable germination. This early spring seeding provides farmers with less work conflict in the spring. Since weeds are a common problem in direct seeding methods, technological improvement in weed management with herbicides has also contributed to this expansion. However, the expectation of high-quality rice with organic weed management requires the future development of nonchemical management strategies. Despite the socioeconomic and population changes and the technological improvements related to direct seeding, direct seeding currently accounts for only 6.9% of the total rice seeding and planting across Japan. The rice quality and recommendations and preferences of consumers as well as the price of rice, continue to be key factors determining transplanting versus direct seeding. Additional research, both technical and consumer-related, is indicated to understand and influence future trends in rice transplantation and direct seeding.

Keywords rice, wet seeding, dry seeding, work conflict, social change, technological improvement

INTRODUCTION

Rice seedlings have traditionally been transplanted to fields (Kaneda, 2010). Seedlings transplanted under submerged paddy conditions offer advantages in terms of production stability and weed competition. Food security and self-sufficient production further encouraged typical farmers to select and use transplanting. Although the heavy labor required in transplanting was a major

constraint, the advantages overcame these constraints. However, societal changes such as migration from rural to urban areas and the transition from self-sufficient, smallholder, and small farms to larger production and commercial farms, have forced farmers to select direct seeding methods rather than transplanting seedlings (Kumar and Ladha, 2011). This trend was previously seen in Asia including a significant conversion from transplanting to direct seeding in Northeast Thailand in the 1990s (Konchan and Kono, 1996). A similar conversion was reported in the 2000s and the 2010s in Cambodia (Kamoshita et al., 2009; Kodo et al., 2021). In these countries, labor shortages were a major constraint to transplanting (Sok et al., 2019), and agrochemicals, such as fertilizers and herbicides, supported the conversion to direct seeding (Kodo et al., 2021). Direct seeding is also common in organic rice farming in Cambodia (Sok et al., 2021).

In Japan, industrial development led to a reduction of available labor for rice production, and a transplanting machine was developed in the 1960s (Hoshino, 1969). As the machine became more common, most farmers continued transplanting seedlings to the present time. However, as the core population of farmers has been continuously decreasing and aging, farmers with surplus capacity are recommended to expand cultivated areas with less labor. The average farm size is continuously increasing, and farms of over 50 hectares (ha) are common in flat topographic farming areas (MAFF, 2022). This development has forced farmers to apply direct seeding in their fields. Accordingly, the area of direct seeding in Japan is now expanding (MAFF, 2023), but it has not increased to the degree observed in other Southeast Asian nations.

Several technical developments have been implemented to support the expansion of direct seeding (Watanabe et al., 2023; Namikawa et al., 2023). However, the contribution of technology in increasing direct seeding has not been sufficiently analyzed.

OBJECTIVE

This study investigates the expansion of direct seeding in Miyagi Prefecture, a representative rice-producing prefecture in Japan. Based on the data, we discuss the contribution of technological improvements to direct seeding and the resultant changes in production and output. Limiting factors and future views are also discussed.

METHODOLOGY

Original data were collected at the request of the Miyagi Prefectural Government. The Miyagi Rice Promotion Division of the prefectural government requested that the Agricultural Development and Extension Centers conduct the investigations. Data collection began in 2005 (MAFF, 2023). The centers interviewed farmers, compiled data from municipalities and agricultural cooperatives, and compensated for the data by inquiring about private companies such as Iseki and Kubota. Select data were published by the Miyagi Prefectural Government (2020). The data in this study were updated and compensated for by the centers to continue the investigation after publication. The data used in study was collected in the year 2023.

RESULTS

Direct seeding accounted for only 1.5% of the rice-planted area in the Miyagi prefecture, 1,017 ha, in 2011 (Fig. 1). The total area of rice planting (transplanting + direct seeding) was 66,400 ha and 60,900 ha in 2011 and 2023, respectively The rate rose to 6.9%, 4,229 ha, in 2023. The farmers initially selected wet seeding, but dry seeding gradually increased. Wet seeding is conducted under submerged conditions after puddling the soil and water. Because water is effective in retaining heat, northern areas of Japan, such as Hokkaido, Tohoku, and Hokuriku, tend to select wet seeding (MAFF, 2023). Coated seeds are generally used to stabilize germination under submerged conditions. Until 2008, Calper coating (Nakamura, 1981) was the only coating method available. Iron coating (Yamauchi, 2017) rapidly increased after its development in 2008 (Fig. 2), as the cost was much less expensive than Capler coating. Iron-coated seeds are seeded on the soil surface,

which increases lodging. To reduce lodging, Bengala and molybdenum (BM) coatings were developed in 2010 (Hara, 2013). However, its expansion was limited due to its difficult management and the propagation of the dry seeding method, which is described below.

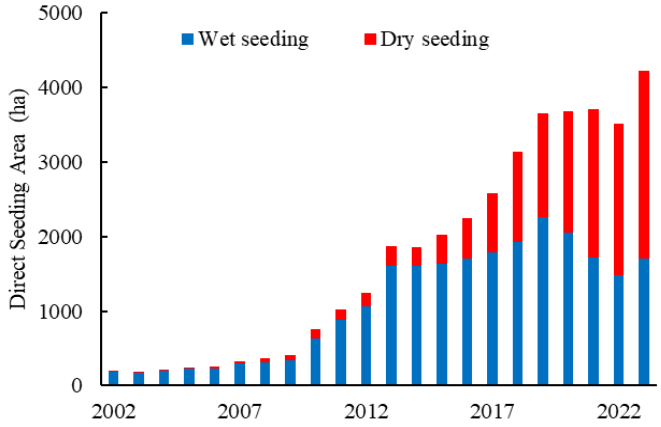
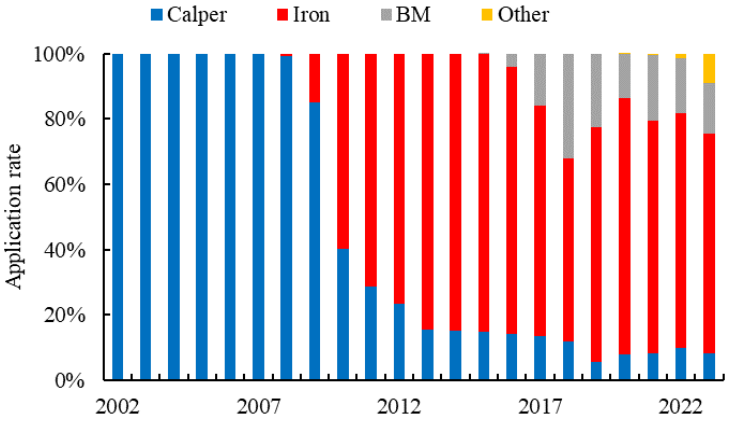
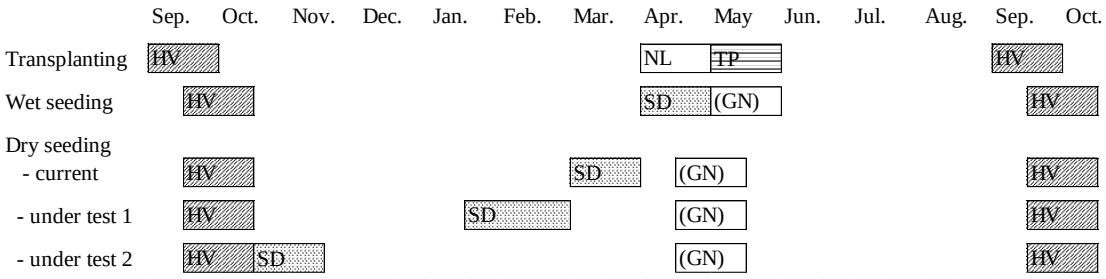


Fig. 1 Changes in the direct seeding area and the ratio of wet and dry seeding in Miyagi Prefecture



BM: Bengala and molybdenum coating

Fig. 2 Changes in wet seeding methods



NL: nursery; TP: transplanting; SD: seeding; GN: germination; HV: harvesting

Fig. 3 Planting management schedule in Miyagi Prefecture

Dry seeding in early spring was first developed in Aichi Prefecture (Hamada et al., 2007) and expanded to other prefectures because it was quite effective in alleviating work conflicts in the spring (Fig. 3). Adaptation to the Tohoku Region has also been developed (Otani et al., 2013; Namikawa et al., 2023). Current dry seeding is set to begin from late March to early April in Miyagi Prefecture. Extension of seeding time (under test 1 in Fig. 3) and seeding in early winter

(under test 2 in Fig. 3; Shimono et al., 2012) had been attempted at the experimental station. Since earlier seeding generally reduces the germination rate, an improvement in germination is required to stabilize production. Snowfall in winter is another problem for dry seeding because it often delays planting. Accordingly, dry seeding is expanding in warmer coastal areas (Fig. 4).

Since Hitomebore is a leading cultivar in Miyagi Prefecture, farmers tended to plant it as the first choice, but started to select other cultivars (Fig. 5). Manamusume has higher productivity and is preferred as multipurpose rice, such as for institutional use and feed rice. Accordingly, the percentage of Manamusume in direct seeding was higher but has decreased in recent years. Sasanishiki is a well-known old cultivar that is favored for its unique taste. The expansion of Sasanishiki was led by farmers, who empirically established its suitability for direct seeding.

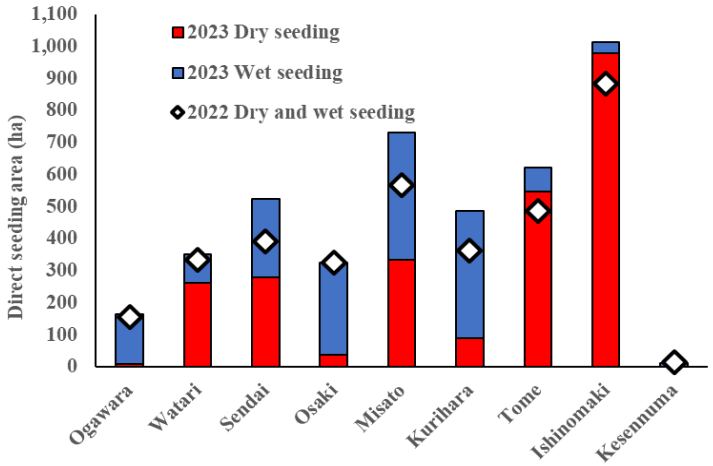


Fig. 4 Planting area of wet and dry seeding in districts in Miyagi Prefecture in 2023

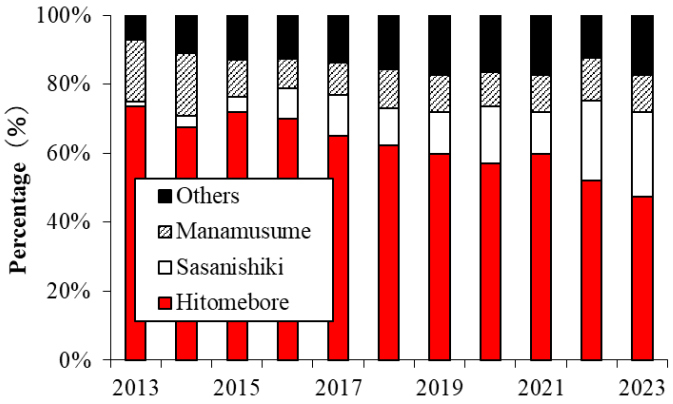


Fig. 5 Percentage of rice cultivars in direct seeding in Miyagi Prefecture

DISCUSSION

The direct seeding area in Miyagi was the fourth largest among the six prefectures in Tohoku Region in 2007 but will be the largest in 2020. As of 2023, direct seeding accounted for 2.5% of the total rice-planted area in Japan and 6.9% of the rice-planted area in Miyagi Prefecture. One of the driving forces in Miyagi for farmers to shift to direct seeding was the Great East Japan Earthquake in 2011. After the resultant tsunami destroyed fields and farmers, the reconstruction of fields and the reorganization of farmer associations proceeded to expand the scale of farms. The standard paddy field plot changed from 0.4 ha to 1.0 ha. One-quarter of agricultural management entities had a farmland area of 30 ha or more in 2020. These changes promoted the expansion of direct seeding. A new and large entity is relatively easy to try new methods to improve economics and sustainability.

The expansion was technically encouraged by the improvement of the direct seeding method, the development of coating material for wet seeding, and the expansion of applicable areas for dry seeding. One of the key developments in wet seeding was the switch to iron coating, which decreased coating costs from 600 yen per kilograms (kg) of seed coated in Calper to 250 yen per kg of seed coated in iron. The development of seeding machines and herbicides for iron coating also contributed to this expansion, enhancing the increase in the direct seeding area after 2010 (Fig. 1). The recent trend toward dry seeding suggests that farmers are more strongly motivated to alleviate work conflicts rather than to stabilize their production. Farmers preferentially welcome dry seeding during early spring or winter because many agricultural activities start in the spring. The cost of the seed coat in wet seeding also appears to enhance the preference for dry seeding, which does not require a seed coat.

Direct seeding has steadily increased, but its percentage remains very low. 7%, in Miyagi Prefecture. As noted, rice transplanting machines have been commonly used, reducing the cost compared to manual transplanting. Our analysis showed that the cost reduction was approximately 20% in Miyagi, even though farmers introduced wet seeding with iron coating instead of machine transplanting (data not shown). Another rationale is that Japanese consumers have a strong demand for high-quality rice. Several experiments suggest that direct seeding does not necessarily lead to lower rice quality (Yoshinaga et al., 2012). However, direct seeding has many factors that cause degradation of rice quality, such as uneven growth and lodging. Optimal control in terms of nitrogen fertilizer application is required to produce high-quality rice, but experimental efforts in direct seeding are limited compared to those for transplanting (Namikawa et al., 2023). Because a cost reduction often results in reduced income due to the lower price of reduced grain, the high price of high-quality rice in Japan seems to have an adverse effect on the expansion of direct seeding. Direct seeding requires the same level of stability as transplanting cultivation in terms of yield and quality.

Weeding is a major problem in direct seeded fields. Since many studies have been conducted, several herbicide application systems have been proposed for each seeding method (Otani et al., 2013; Okawa, 2020). Herbicides for rice fields are generally recommended for flooded conditions. Accordingly, farmers need to carefully control water and herbicides depending on the growth of rice and weeds, which vary among seeding methods. General systemic herbicide application can provide almost no weed condition if farmers properly apply it based on the instructions. Consequently, weed management control no longer appears to be a limiting factor in the expansion of direct seeding, but weeds can still be a serious problem, especially under labor- and cost-saving cultivation (Ishibashi et al., 2020). Further technical development is required for weed control. In particular, consumers have recently tended to prefer environmentally friendly agricultural production such as organic rice. Therefore, the development of non-chemical weed control management is necessary.

CONCLUSION

This study revealed that several socioeconomic factors were associated with the expansion of direct rice seeding in Miyagi Prefecture and that the development of seeding methods was one of the driving forces. Farmers are gradually adapting to new seeding methods. Although the development of seeding methods is not adequate to facilitate a large change from transplanting to direct seeding, the increase in good practices will eventually make direct seeding more common. The attempts to improve direct seeding in Japan will also contribute to further improvement of rice productivity in Asia where direct seeding has become a major planting method.

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