The Current Adoption of Dry-Direct Seeding Rice (DDSR) in Thailand and Lessons Learned for Mekong River Delta of Vietnam

Working Paper No.273

CGIAR Research Program on Climate Change,
Agriculture and Food Security (CCAFS)

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Abstract

With support from the CGIAR Research Program on Climate Change, Agriculture and Food Security in Southeast Asia (CCAFS SEA), a joint study trip was organized for Vietnamese rice researchers, extension workers, as well as local decision makers, to visit Thailand in April 2018. The goal of the study trip was to observe and learn the experience of Thai farmers on the large-scale adoption process of dry-direct seeding rice (DDSR), a viable alternative to address regional scarcity of fresh water in irrigation caused by drought and salinity intrusion in the Mekong River Delta.

In this trip, the provincial rice research departments and its centers in Thailand gave the Vietnamese team updates on their progress on the implementation and adoption of DDRS throughout the country. The policy mechanisms and finance support from stakeholders (i.e., government, private sector) who favor the application of DDSR were also shared and discussed. During the visits to farmer field sites, the team was introduced to existing techniques and equipment of DDRS being applied by Thai farmers and local organizations.

The following main conclusions were noted: 1) the major drivers of the shift from puddled transplanting or wet sowing to DDSR are the rising scarcity of water and labor. DDSR can be a valuable rice culture to address the emerging water and labor crises for not only irrigated rice areas but also rainfed rice; 2) the precise land leveling, suitable cultivars, good crop establishment, precise water management, and effective and efficient weed and nutrient management are key prerequisites for the success of DDSR; and 3) anticipatory research and development strategies need to be developed for areas where DDSR is likely to be adopted. This is to sustain DDSR on a long-term basis.

Keywords

Direct-dry seeding rice, irrigation, climate-smart agriculture.

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Acronyms

CCAFS SEA	CGIAR Research Program on Climate Change, Agriculture and Food Security in Southeast Asia
CE	crop establishment
CLRRI	Cuu Long Delta Rice Research Institute
DDSR	dry-direct seeding rice
ENSO	El Niño-Southern Oscillation
IMHEN	Institute for Meteorology, Hydrology and Environment
MARD	Ministry of Agriculture and Rural Development
MRD	Mekong River Delta
VAAS	Vietnam Academy of Agricultural Sciences

Introduction

Vietnam is considered one of the severely affected countries by climate change. This is most evident in the country's Mekong River Delta (MRD), which produces about 50% of the total amount of food in Vietnam and ensures food security and livelihoods for approximately 70% of the region's population. As impacts of the recent El Niño-Southern Oscillation (ENSO), severe drought and salinity intrusion have been occurring in the MRD and have caused varying degrees of damages to agriculture and to the livelihoods of people in the region.

In relation to this crisis, on 15 March 2016, the Vietnamese government and the United Nations Development Programme (UNDP) organized a meeting with donors, international organizations, and other partners to discuss the joint efforts for drought response and recovery. Another meeting, which was presided by Minister Cao Duc Phat of the Ministry of Agriculture and Rural Development (MARD) and the UN Resident Coordinator, on 30 March 2016, was held to report the recent rapid assessments of current natural hazards. During this meeting, MARD recognized that this crisis and its subsequent effects will recur in the future; hence, there is a need to prepare and plan for the necessary measures. To realize this goal, the different stakeholders called for short-, medium- and long-term support from the international community.

As a response to this urgent call, the CGIAR Research Program on Climate Change, Agriculture and Food Security in Southeast Asia (CCAFS SEA), in collaboration with the Vietnam Academy of Agricultural Sciences (VAAS) and Cuu Long Delta Rice Research Institute (CLRRI), organized a joint study trip in Thailand to observe and learn about the dry-direct seeding rice (DDSR) process. The DDSR is being studied as a viable alternative to address freshwater scarcity in irrigation caused by drought and salinity intrusion currently transpiring in the region. The recommendations from the study trip may support the short-, medium-, and long-term planning in response to the impacts of climate change in MRD.

Objectives

The study trip aimed to achieve the following objectives:

1. Conduct a first-hand observation and assessment of the degree and extent of adoption of DDSR in Thailand;
2. Gather the lessons learned from the location-specific and regional DDSR adoption in Thailand and forward them to the relevant agencies in MRD of Vietnam to help the region,

especially the drought- and saline-affected areas, improve their preparedness and coping capacity during the dry crop season; and

3. Identify potential and appropriate machines or equipment for DDSR in MRD of Vietnam.

Background/Context

Rice production in Thailand

Rice is one of most important food crops in Thailand (IRRI 2018). The total area planted with rice is estimated to be about 11 million hectares (ha), equivalent to almost 40% of the total crop land area (Kupkanchanakul 2000; IRRI 2018). There are two annual rice-growing periods in Thailand, the wet season and the dry season. In terms of area covered and share in the production, the wet-season rice accounts for 88% of the annual rice area and 80% of the production. Dry-season rice accounts for 12% of the area and 20% of production (IRRI 2018). Since 2007, the rice land during the wet season has averaged about 8.8 million ha and is heavily dependent on monsoonal weather systems. In this regard, 70% of the crop is rainfed. The remaining 30% lies primarily in the river basin of the western Chao Phraya and is irrigated via water stored in mountain reservoirs (USDA 2017).

Rice lands can be classified as irrigated, rainfed lowland, deepwater, and upland ecosystems (IRRI 2018). More than 80% of the rice-growing areas in Thailand are under rainfed conditions (Kupkanchanakul 2000). Rice is usually grown only once a year in the wet season, when the monsoon rain is the only water source for rice cultivation. The remaining 20% of the areas are under irrigated conditions wherein water supply is always available. Because of the availability of water, rice can be grown in both wet and dry seasons in irrigated areas (IRRI 2018).

In term of land classification, rainfed lowlands are the major contributor. About 75% of the total wet-season rice area is in rainfed lowlands, accounting for 68% in the production. Deepwater lands only cover 1.92% of the total wet-season rice area, leading to a 1.17% share in the production. The production share coming from the uplands is even smaller – 0.32% of the production harvested from farmlands that constitute only 0.58% of the total wet-season rice area (Kupkanchanakul 2000).

The total dry-season rice area, which averages 2.0 million ha, is about 80% irrigated, and accounts for roughly 30% of the total annual rice production (USDA 2017). Rice cultivation during the dry-season is heavily focused on irrigated paddylands in the Lower North and Central Plains region where are intensively cultivated alluvial area (Molle and Srijantr 2003). During the rainy season, rice covers the major part of the Central Plain region, which accounts for about one-fifth of the total cultivated rice land of the country in the wet season (IRRI 2018). These areas are essentially the country's major rice bowls in Thailand because of fertile soil with good irrigation infrastructures and agricultural mechanization (USDA 2017).

The country's annual exportable rice surplus is also produced in those areas and usually comes from the dry-season harvest. The Bhumipol and Sirikit reservoirs, which are located in the northern headwaters of the Chao Phraya River Basin, are two major sources of irrigation. Together, they provide 80% to 90% of the irrigation supply dedicated for cultivating rice (USDA 2017).

Thailand is divided into four regions:

1. **Northeastern region**. Almost one-third of the land area—about half of which is rice land—is located in this region. However, the average size of rice farms is smaller compared to other regions. Irrigation potential in this region is limited due to undulating topography. The area under direct-dry seeding is the largest with 6.3 million ha of rice. In this region where rainfed rice cultivation is commonly practiced, direct-dry seeding is replacing transplanting to achieve more successful plantings and save more labor cost (Cosslett and Cosslett 2018).

2. **Central region**. This is an intensively cultivated alluvial area. The average farm size is large, and a major portion of rice land has access to irrigation facilities, allowing many farmers to grow two rice crops during the year. Almost 75% of the dry-season rice grown under irrigated conditions is in this region. The main rice surplus comes from this region as well (Cosslett and Cosslett 2018).

3. **Northern region**. The northern region contains almost one-third of the land area of Thailand. On one hand, upland rice is grown in the lower altitudes of high hills and in upland areas. On the other hand, lowland rice is grown mainly in lower valleys and on some terraced fields where water is available (Cosslett and Cosslett 2018).

4. **Southern region**. It only accounts for 6% of the total rice land. As a result, there is always a shortage of rice for local consumption (Cosslett and Cosslett 2018).

The general policy for rice production in Thailand is to produce rice for self-sufficiency and surplus for export to earn foreign exchange (Kupkanchanakul 2000). Currently, it aims to produce about 22-23 million tons of paddy annually, wherein 13-14 million tons will be dedicated for domestic consumption while the remaining 8-9 million tons, 5.5 million tons of which is milled rice, is reserved for export (USDA 2017, IRRI 2018). Major production comes from the wet-season rice crops and is being supplemented by crops harvested during the dry season.

Rice production in Vietnam’s Mekong River Delta

MRD is an agro-ecological region covering 13 provinces in the southern part of Vietnam. It has a total area of about 4 million ha, wherein 2.6 million ha is agriculture land, contributing some 48% of national food production, more than 85% of annual rice exports, 57% of national aquaculture production, and 41% of Vietnam’s fishery catch (GSO 2018). This makes MRD of Vietnam the largest agriculture and aquaculture production region in the country (CCAFS-SEA 2016).

In particular, the region is critical to Vietnam’s national agricultural production. MRD-based agricultural products not only help in ensuring food security and providing livelihoods to about 70% of the region’s population, but also serve as exports that will be distributed to the international market.

The primary livelihood in Mekong Delta is rice cultivation, employing 60% of its inhabitants. More than 2 million ha of agricultural land is dedicated to rice production. Agricultural land in the MRD can be further segmented into sub-regions with distinct characteristics: 1) the eastern part (from the Tien River towards Ho Chi Minh City), which has low agriculture potential due to acid sulfate in the soils; 2) the central part (between the Tien River and the Hau River), which is the horticultural production area; and 3) the western part, which is the area for rice and aquaculture production. Unfortunately, the western sub-region is also often affected by salinity intrusion (CCAFS-SEA 2016).

With the help of flood and salinity control projects, the irrigated areas in MRD saw a major expansion—from 52% in 1990 to 91% of croplands in 2002. These irrigated areas are conducive for more agricultural production, as farmers can grow two to three rice crops per year, even in the coastal regions (Tran 2006, Kajisa 2006). This has led to remarkable increases in areas devoted to rice, as well as in rice production and yield.

The rice-planted area did not change from 1976 to 1986 but expanded in a rapid rate from 2.3 million ha in 1987 to 3.9 million ha in 2000. In 2011, the recorded rice-planted areas further expanded to 4.1 million ha. The analysis of MODIS remote sensing images from 2000 to 2013 shows that the area for single rice crops and double rice crops tend to decrease while that of triple rice crops and shrimp-rice tend to increase (ACIAR 2014).

Table 1: Rice cropping systems in MRD

Cropping systems	**Area (1000 ha)**			**Percentage (%)**		
	2000	**2005**	**2010**	**2000**	**2005**	**2010**
Single rice	337	97	68	16	5	3
Double rice	1378	1133	1120	64	56	52
Triple rice	433	650	731	20	32	34
Shrimp-Rice	14	145	225	1	7	10
Total	2162	2025	2144	100	100	100

(Source: ACIAR 2014*)*

In this regard, 90% of Vietnam's exported rice comes from the MRD, helping the country become the one of largest rice exporter in the world (Nguyen and Liu 2019). Similarly, rice production had grown 3.6 times, from 6.4 million tons in 1987 to 23.2 million tons in 2011 (GSO 2012). In 2016, rice production in the region was recorded at 25 million tons (55% of national value) already. The provinces with the largest rice areas are An Giang, Kien Giang, and Dong Thap. Altogether, these provinces yield almost 50% of the MRD rice production (CCAFS SEA 2016).

The rice cropping calendars vary on these areas. For instance, those that are affected by salinity intrusion and flooding are marked differently. Generally, the difference between cultivation periods of a crop in a certain area is from two to four weeks (CCAFS SEA 2016).

Rice production and climate change in Mekong River Delta

The impacts of climate change are evident in MRD. Specifically, sea level rise in low lying areas at the mouth of the Delta, increased rainfall, increased number of extreme weather events, rising average temperatures, and increased salinity intrusion plague the region (ICEM 2012).

The sea level around MRD has already risen by 20 cm since 1901. This rise must be alarming, given the low elevation of the area. Average temperatures in MRD have increased in recent years as well. Records from the Institute for Meteorology, Hydrology and Environment (IMHEN) show an average temperature rise of $0.5^{o}C$ during the period 1955-2005 across Vietnam. Specifically, Can Tho City, together with the DRAGON Institute, reported an average temperature increase of $0.5^{o}C$ within its vicinities over the last 30 years (CCAFS SEA 2016).

Salinity intrusion, caused by rising sea levels, has also increased in MRD. According to the 2009 Mekong River Delta Climate Change Forum Report, it had already reached beyond the inlands, affecting a lot of areas in the region. Salinity intrusion reduces water flow and thwarts the restoration of delta silt (Padilla 2011).

Aside from its adverse impacts on the water resources, salinity intrusion, as well as drought, is affecting rice production in vast land areas. In fact, the impacts of salinity intrusion and drought together can already be observed during the reproductive stage of rice and remain usually until its late vegetative stage (February and March). This rendered salinity-tolerant varieties ineffective as their tolerance to salinity is only during the seedling or vegetative stage (Nguyen 2015, CCAFS SEA 2016).

Farmers who irrigated their fields with saline water suffered "burnt" fields and those who did not suffered from drought. In some cases, farmers had to delay the planting for the next rice crop season because fresh water is either scarce or could not be used due to salinity intrusion or because the start of the rainy season no longer coincides with the puddling and crop establishment (CE) stages. Such impacts are devastating especially to the side of the farmers: yields were cut in half; there were even cases of total loss (CCAFS SEA 2016).

As a response, DDSR was introduced in MRD 15 years ago. It was believed to have an immense potential as an alternative to the conventional practice of puddled transplanting or sowing, which would then help in overcoming emergent resource constraints, especially freshwater scarcity in the context of climate change. DDSR, as perceived since then, would also address the increasing cost of cultivation in Vietnam. However, DDSR has yet to reach its full potential in the country primarily because of the unavailability of a complete DDSR production technology. It is therefore important to learn from Thailand where DDSR is now widely practiced throughout rainfed lowland areas.

Methodology of gathering data and other information

The team

The team was composed of experts in rice crop management, rice farming practices, and climate change research (Soc Trang Department of Agriculture and Rural Development, CLRRI, and VAAS), as well as local experts on rice production (The provincial rice research departments and its centers in Thailand) (The members of the team are listed in Appendix 1).

Information collection methods

Information was collected from field observations, key informant interviews with the officials from the provincial rice research departments and their centers, and face-to-face interviews with key Thai rice farmers.

The following were the guide questions asked during the visit:

1) How big is the area under DDSR? How do they conduct large-scale DDSR in Thailand?

2) Why do farmers practice it? What are the advantages and disadvantages of DDSR? What policies favor the application of DDSR in Thailand?

3) How do they do it (manually or mechanized)? What are the critical steps? What steps are mechanized? How big is the mechanized area?

4) What makes DDSR suitable for their area?

5) What is the key to the success of DDSR in the area?

6) What makes the Thai experience applicable to Vietnam? What makes it not applicable?

7) What does Vietnam need to apply large-scale DDSR? Where can it be applied in a large scale? In what cropping season can it be applied? What varieties will work?

8) Is there a need for new policies in Vietnam? What policies are needed in Vietnam to support DDSR?

Limitations

The team only visited the locations identified prior to the visit and mainly based on key informant discussions and on knowledge about the region of the participating experts. The team did not conduct a detailed collection of data that can be used for in-depth analysis. Furthermore, the recommendations focus on the possible DDSR practices and technologies that could be suitable and feasible in MRD.

Key observations and findings

The key observations of the team listed below served as the bases for the subsequent recommendations. For a deeper understanding of these key observations, please refer to the detailed daily highlights of the field assessment in the Appendix.

Main drivers of the DDSR adoption in Thailand

Water scarcity

Water scarcity is prevailing, which leads to a diminishing water supply for agriculture. Direct Seeding Rice (DSR) provides some opportunities for saving water. Both Dry-DSR and Wet-DSR are more water-efficient and own an advantage over conventional transplanting or sowing. Similar in MRD of Vietnam, Wet-DSR is widely adopted in Thailand.

In fact, more than 95% of irrigated rice areas in the Central Plains of Thailand are applying Wet-DSR. However, with increasing shortage of water during the dry season, DDSR with zero or minimal tillage with corresponding potential savings on both labor and water is spreading rapidly in the northeast region of Thailand and believed to have higher potential in the country’s Central Plains as well.

Labor shortage and increasing labor wage

In Thailand, the labor force involved in agriculture is declining annually at a rate of 0.25–0.40%. Specifically, the agricultural labor force already dropped from 40% in the 1960s to 30–35% today. One major factor is the labor-intensive nature of the conventional transplanting or sowing. Both land preparation (puddling) and crop establishment methods (transplanting or sowing) require a large amount of labor.

Because of the high labor demand at the time of transplanting, worsening labor scarcity, and rising wage rates (250-300 THB per person per day), farmers are opting for direct seeding, which only needs about 5-10 working days per hectare. This is more economical than transplanting, which requires 25–45 working days per hectare.

Crop intensification and recent developments in DDSR production techniques

Economic incentives through the integration of an additional crop (i.e., crop intensification) are another reason for the rapid spread or adoption of DDSR. For instance, in the northeastern part of Thailand, DDSR facilitated double cropping instead of single cropping of transplanted rice.

Early establishment and short-duration varieties (95–105 days) also allowed early harvesting of DDSR, leaving enough time and rainfall to grow the next rainfed crop. DDSR is now covering almost 100% of the northeast region of Thailand. It must be noted that the availability of high-yielding short-duration varieties and new herbicides for weed control largely made this shift technically viable.

Rising interest in integrated crop management

Declining or stagnating crop productivity and a deteriorating resource base in cereal systems led to the promotion of conservation tillage-based agriculture. It involves zero or minimal tillage followed by row seeding using a drill.

Conservation tillage, when it utilizes crop residue as mulch with improved crop and resource management practices, is termed integrated crop management (ICM). However, zero tillage is only practiced in small areas in the Central Plains, the main “rice bowl” of Thailand. Paddy rice in the country is still widely grown under conventional intensive tillage (puddling) and crop establishment (transplanting).

Types of DDSR in Thailand

DDSR is characterized by the following: 1) the soil may have undergone dry land preparation before dry seeding. This is done either through conventional tillage or through zero tillage. It must be noted that dry preparation is typically practiced for upland rice but can also be done for lowland field; 2) dry seeds are sown in dry soil; and 3) seeds are sown either by broadcast or in rows. Seeding in rows can be accomplished by hand or use of seeding machines.

In Thailand, DDSR is established using several different methods, including:

1. Broadcasting (sowing seed by scattering it) of dry seeds on non-puddled soil after either zero tillage (ZT dry-BCR) or conventional tillage (CT-dry-BCR). About 60−80 kg of seeds is broadcasted uniformly by hand. In rainfed rice ecosystems, farmers often sow onto a dry soil surface, after which, they will incorporate the seed either by ploughing or harrowing. Germination occurs following rains or floods.

2. Drilling of seeds in rows after conventional tillage (CT-DDSR), reduced tillage using a power tiller-operated seeder (PTOS) [RT (PTOS)-dry-DSR] or zero tillage (ZT-DDSR).

- Precision equipment, such as the Turbo Happy Seeder, can be used to drill seeds. One can drill 80−100 kg of seeds per ha with this equipment. Seeds will be placed in the dry soil by the machine and will be irrigated afterwards. In this technique, fertilizers can be applied at the same time as the seed. Manual weeding is also easier in machine-drilled crops than in broadcasted crops.
- For CT-DDSR and ZT-DDSR, a seed-cum-fertilizer drill is used, which, after land preparation or in zero-till conditions, places the fertilizer and drills the seeds. The PTOS is a tiller with an attached seeder and a soil-firming roller. It tills the soil at shallow depth (4–5 cm), sows the seeds in rows at adjustable row spacing, and covers them with soil. The soil is lightly pressed for better seed-to-soil contact in a single pass. Drill seeding is preferred over broadcasting in irrigated or favorable rainfed areas in both developed and developing countries as it allows line sowing and facilitates weed control between rows, saves seeds and time, and provides better (CE).

3. Dibbling method in a well-prepared field: Dibbling or hill planting is usually practiced along mountain slopes or where plowing and harrowing are difficult to perform. In this method, there will be a long wood or bamboo pole with a metal scoop attached at the end for digging holes. The seeds will be then dropped into the holes and will be covered with soil.

Figure 1: Thai rice farmer sowing seed by scattering it (Broadcasting dry seeding)

Figure 2: Thai rice farmer sowing seed by using a power tiller-operated seeder (Drill dry seeding)

In general, DDSR avoids nursery puddling operations, raising, seedling uprooting, and transplanting, and thus further saves labor use. Since land preparation in Thailand is mostly mechanized, there are more savings in machine labor than in human labor in this operation (Farmers and local staff reported 30-40% savings in machine labor requirement in ZT-DDSR compared with conventional practice on transplanted rice).

In addition to labor savings, the demand for labor is spread out over a longer period in DDSR than in transplanted rice. Conventional practice requires much labor only in the critical operation of transplanting, which often results in a shortage of labor in other phases of rice cultivations. The spread-out labor approach helps in utilizing family labor and having less dependence on hired labor.

Advantages and disadvantages of DDSR

DDSR has the potential to provide several advantages to farmers and their environment over conventional practices of puddling and transplanting.

The advantages of DDSR:

- It requires less labor: labor savings averagedwith an average of 29% in DDSR as compared to conventional practices;
- It reduces use of water for land preparation: water savings ranged from 15% to 35%;
- It reduces loss of irrigation water and prevents percolation because of fewer soil cracks.
- It reduces cost of cultivation: the largest reductions in cost occurred in practices in which minimal or zero tillage was combined with DDSR. Under DDSR, these reductions were largely (5% to 35%) due to drops in either labor cost or tillage cost or both; and

- It utilizes early rainfall and harvest seasons: DDSR allows timely planting of subsequent crop due to early harvest of DDSR crop by 7–14 days.

Disadvantages of DDSR:

- More competition from weeds as compared to wet direct seeding or transplanting due to the absence of standing water;
- Increases dependence on herbicides;
- Good land preparation, leveling, and water management are needed for a uniform crop establishment;
- Rats and birds can severely damage seeds if they are not well-covered with soil after seeding; and
- Sudden heavy rain immediately after seeding can adversely affect crop establishment.

Weeds are a major constraint to the success of DDSR in Thailand. They are specifically more problematic in DSR than in puddled transplanting because: 1) emerging DSR seedlings are less tolerant against concurrently emerging weeds; and 2) in DDSR, the initial flush of weeds is not controlled by flooding or standing water. Weedy rice is highly competitive and causes severe rice yield losses. It could also become a major threat to rice production where DDSR replaces conventional practices.

Dry-direct drill seeding

The most important prerequisites for successful dry-direct drill seeded rice are: 1) precise land leveling, 2) good CE, 3) precise water management, and 4) effective and efficient weed management. These are described in detail below:

Precise land leveling:

- Good land leveling is an important entry point because it: 1) facilitates stable CE; 2) allows precise water control and good drainage; 3) reduces the amount of irrigation water needed; 4) increases cultivation area because of fewer bunds; 5) improves efficiency of input use (water, nutrients, and agrochemicals); and 6) increases crop productivity.
- Good land leveling is best achieved using laser-assisted leveling. Well-maintained fields require laser leveling once every 3−4 years. Aside from laser leveling operations, the field can be leveled using a drag bucket. A levelled field allows planters or drills to place seeds more precisely and allows a more uniform irrigation. A levelled field also reduces weed pressure and helps control water.

- It takes approximately eight hours to level one hectare of land using the bucket leveler. After land leveling, the soil must be lightly tilled by 1−3 cm to make it less compacted.

Crop establishment (CE):

- Uniform crop development with optimal plant density is crucial to achieve good yields for any system, including dry-drill seeded rice. Good CE depends on several factors, including land preparation, planting date, seed rate and seed preparation, types of planting machinery used, and depth of seeding.

- Planting time: Rice in Thailand is mainly grown during the wet season. To utilize monsoon rain, the optimal time for planting wet-season rice is about 10–15 days prior to the start of the monsoon—determined by forecast or historical weather data. Specifically, land preparation must be finished before the start of monsoon and seeds must be sown before the start of the wet season to take advantage of pre-monsoon rainfall and eventually promote early crop growth.

  The DDSR method is traditionally practiced in the rainfed uplands of Thailand. However, recently, this method is now being recognized in some irrigated areas such as those in the Central Plains where water is becoming scarce during dry season.

- Priming of seeds and seed treatment: Priming of seeds has shown positive effects on the emergence, yield, and quality of DDSR. In dry-drill seeding, good CE is hampered by hot temperatures resulting in dried soil subsurface. Hence, priming of seeds (pre-hydration) allows early and improved emergence and early vigor.

  Priming is accomplished by soaking seeds in water for 10–12 hours and then drying them in shade prior to seeding. This process allows the seeds to flow freely during seeding operations. However, seeds should be sown shortly after priming to avoid deterioration. Emergence of primed seeds will be affected if seeds encounter moisture stress initially.

- Planting machinery such as drills or planters: For accurate and precise seeding, the crop should be drilled using a multi-crop planter with a precise seed-metering system (e.g., with inclined plate, cupping system, or vertical plates). With these precise seed-metering planters, rice can be established with a lower seed rate. More precise plant-to-plant spacing can be maintained as well. Normal fluted roller-type seed-cum-fertilizer drills are less suitable for drill seeding of rice as the seeds fall continuously.

This makes maintaining the seed rate difficult and the plant-to-plant spacing as accurate and precise as compared with inclined- or cupping- or vertical-plate seed-metering systems. Some of the machines that can be used for seeding rice include turbo seeder, PCR planter, double-disc coulters, and rotary-disc drill, among others.

Precise water management:

- Precise water management, particularly during the CE phase (first 7–15 days after sowing), is crucial for dry-drill seeded rice. In this regard, the soil must be kept moist but not saturated to avoid seed rotting. After sowing in dry soil, a flush irrigation must be applied to wet the soil, especially if it is unlikely to rain before saturating the field at the three-leaf stage.

  This practice will not only ensure good rooting and seedling establishment but also enhance the germination of weed seeds. Therefore, early weed control with an effective pre-emergence herbicide is crucial to check weed emergence and growth.

- Precise leveling is also important for an equal allocation of water resources as well as for an easy drainage, which is needed during the CE phase of DDSR. After CE, the following broad water management options are available: 1) continuous flooding; 2) frequent irrigation with DDSR complemented with safe alternate wetting and drying (AWD), which involves flooding the field with shallow depth (5 cm) and re-irrigating a few days after the water disappears; 3) frequent irrigation where water scarcity for irrigation limits rice yields; and 4) no irrigation under rainfed conditions. Given the aim of achieving high yields of DDSR with less water, option 2 is preferred although this will still depend on the availability of irrigation water.

Effective and efficient weed management:

Land preparation, including tillage and precise land leveling before crop planting, plays a key role in controlling weeds in dry-drill seeded rice. Precise land leveling controls weed because it allows a sound water control and improved herbicide efficiency. This has been shown to be effective in reducing the weed population by up to 40%, the labor requirement for weeding by 75%, and weeding cost by 40%.

Scaling-out the mechanized direct dry seeded rice (mechanized DDSR) in Thailand

Several projects supported by organizations and the Thai government have now introduced thousands of seed drills to small- and large-scale farmers in rainfed lowland rice areas in the northeastern part of Thailand. Their target is to reduce production cost and increase rice productivity.

The Thai government, through its rice department—the Ministry of Agriculture and Cooperatives in particular—has launched a large-scale farming model aiming to reduce production cost. In the recent years, approximately 50,000 farmers in more than 124,800 ha of rice-growing areas have adopted the large-scale farming model where they share a plot of land within their group and grow their crops. Thousands of seed drills for those mounted on the two-wheel and four-wheel tractors have been introduced to the farmers in the project.

The mechanized DDSR is now widely adopted throughout rainfed lowland areas in northeast Thailand. However, there are still limitations involving the technologies. Early rainfall in the wet season limits the use of the seed drill. Problems in field condition, as well as identifying and calculating the rate of fertilizer application, are still difficult for farmers to perform. Therefore, further researches are needed to solve such problems and improve the efficiency of using mechanized DDSR. Moreover, modern technologies and studies on the appropriate timing of mechanized DDSR, weed and pest management, and easier protocol for fertilizer application are required to support farmers in both small- and large-scale rice farming.

Conclusions and Recommendations

Conclusions

In Thailand, conventional puddled transplanting or sowing is the most widespread practice in rice production. Because of the water-, labor-, and energy-intensive nature of this system, and rising interest in ICM, DDSR with zero or reduced tillage (ZT–RT) has emerged as a viable alternative. During the trip, the team tried to answer several questions pertaining to DDSR and discussed an integrated package of technologies, specifically for ZT/RT-dry-DSR, to deal with the fast-emerging water and labor crises.

Here are some conclusions based on observations and discussions from the assessment trip:

- The distinct types of DDSR. Crop establishment can vary from broadcasting manually or mechanically using a drill or a drum seeder, to applying the manual dibble method on non-puddled soil. In the Central Plains of Thailand, water is relatively more available. Thai farmers apply Wet-DSR without making a change in tillage. However, in areas such as northeast Thailand where both labor and water are emerging as major constraints, farmers are interested in DDSR with zero or reduced tillage.

- The major drivers of the shift from puddled transplanting or wet sowing to DDSR. The rising scarcity of water and labor are the major drivers for this shift. Puddled transplanting or wet sowing mainly uses freshwater and requires enormous amounts of labor. Primarily because of labor shortages, direct seeding (mostly wet seeding) is widely adopted in Thailand.

Furthermore, high labor demand during the critical operation of transplanting leads to shortages and increasing labor costs. Water for agriculture is also becoming a scarce resource in many rice production areas in northeast Thailand. These factors have pushed many Thai farmers to shift to some forms of DDSR, which require less water and labor.

- Experiences in Thailand have shown a compelling evidence in terms of savings—about 12–35% of irrigation water under DDSR systems. The irrigation water productivity of DDSR methods was higher than in conventional practice. Labor savings of up to 35-45% in DDSR compared with conventional practice have been reported, with the level of savings depending on tillage, CE method, and level of mechanization. Zero tillage-DDSR saves more labor than Wet-DSR because of additional savings in land preparation.

- Generally, rice varieties bred for puddled transplanting or wet-sowing are used in direct seeding (Wet-DSR and DDSR) in Thailand. The lack of suitable varieties could be a major constraint in achieving maximum potential of direct seeding.

- Realizations that optimal plant architecture could be critical to the success of DSR (Wet-DSR and DDSR) in Thailand. This has led to the development of management practices that enhance stand establishment, including land leveling, seeding (depth, density, distance) with residue, irrigation, and weed control.

Seeding at an optimal depth and distance not only reduced the seed rate but also helped in overcoming spikelet sterility and lodging problems. Both agronomic management and a suitable variety with appropriate traits are needed to achieve maximum potential under DSR, especially DDSR.

- The lessons we have learned from Thailand where direct seeding (especially DDSR) is widely adopted: In Thailand, more than 90% of the irrigated rice is applying Wet-DSR for the past few decades already. DDSR is mainly applied in rainfed rice areas in the northeastern part of Thailand. The experiences in Thailand have shown that precise land leveling, suitable cultivars, good crop establishment, precise water management, and effective and efficient weed and nutrient management are the key prerequisites for the success of DDSR.

Establishing a strong herbicide industry that yields affordable and appropriate herbicides also plays a crucial role. Therefore, anticipatory research and development strategies need to be developed for areas where direct seeding is likely to be adopted. This is important for DDSR to be sustainable on a long-term basis.

Projections and trends seem to suggest that DDSR will likely be a good rice culture to address the fast-emerging water and labor crises for not only irrigated rice areas but rainfed rice areas as well. In general, this is an important lesson for Vietnam, a country that can shift to DDSR.

Recommendations

These are the recommendations that can be applied in the MRD of Vietnam for the future wide-scale adoption of DDSR:

1. As one single practice cannot make a successful DDSR performance or application, a full technical package of DDSR cultivation should be developed and proposed to the farmers.

    - Development/breeding/selection of new rice varieties for dry-direct seeding along with proper management practices can help in wide adoption of DDSR. The selection of suitable cultivars with characteristics such early crop vigor, short statured cultivars, short duration, and tolerance to drought and/or saline intrusion can further increase water-use efficiency.

    - Selecting appropriate soil types, as well as applying precise land leveling and proper water management, is recommended to enhance water-use efficiency and productivity.

    - Seed priming technology, proper sowing time, and optimum seed rate should be practiced to address the poor establishment of rice in dry conditions.

    - Proper systematic weed monitoring program in relation to integrated weed management strategies on sustainable basis should be developed to tackle the weeds associated with switching to DDSR.

    - The appropriate machine types (e.g., power tiller-operated seeder) should be selected not only to improve establishment efficiency of rice, but also to save labor use.

    - Biotechnology should also be applied to resolve minor issues such as lodging, nematode infestation, and diseases, among others.

2. DDSR-applicable regions must be identified in MRD. These areas must be experiencing serious problems on timely wet sowing and/or transplanting of rice due to freshwater scarcity resulting from saline intrusion and prolonged drought season.

3. It is essential to establish field demonstrations/models. They will help in raising the farmers' interest in DDSR adoption and promoting the seeders to the farmers.

Even with regional scarcity of water, increasing labor wages, and other major issues, DDSR can still be one of the most viable options to attain sustainable yields without overexploiting the available freshwater resource in MRD. In considering usual drought and saline intrusion, as well as unstable water supply situations in MRD, it is anticipated that farmer adoption of DDSR system will increase due to the benefits of increased profitability, better grain yield of improved cultivars, and higher water productivity.

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APPENDICES
Appendix 1 - Program of Activities

Date	Activities	Persons met
22nd April (Sunday)	Hanoi—Bangkok	
23rd Apr (Monday)	7:30—9:30 Bangkok-Ayutthaya	
	9:30-11:30 Visit to Ayutthaya Rice Research Center - Meeting and discussion - Learning pre-geminated dipping and meet pre-germinated dipping machine producer	Mrs. NittayaRuensuk, Agricultural Research Officer (Senior Professional Level), PathumThani Rice Research Center, Thanyaburi, PathumThani province Mr. KritkamolPaothong, Agricultural Research Officer (Senior Professional Level), Bureau of Rice Research and Development, Ayutthaya Rice Research Center, Ayutthaya province
	13:30—17:00 Visit to farmer field at Ayutthaya	MrPichitKeatsanphon, farmer at Ayutthaya
	17:00-19:00 Ayutthaya-SuphanBuri	
24th Apr (Tuesday)	8:30—10:30 Visit to farmer fields at SuphanBuri province to find out pre-germinated broadcasting by machine 10:30-12:00 Visit to Thailand Rice Science Institute, SuphanBuri	Mr. SontayaTrisvtipol, farmer at SuphanBuri province Mr. ChalermchartLuechaikham, Agricultural Research Officer (Senior Professional Level), Thailand Rice Science Institute, SuphanBuri province Ms. MarsutonSanyapeung, Agricultural Research Officer (Practioner Level), Thailand Rice Science Institute, SuphanBuri province
	12:00—13:30 SuphanBuri–Chainat	

	13:30-16:30 Visit to farmer field at Chainat to learn laser and levelling and dry seed dipping	Ms. DuangpornVithoonjit, Senior Rice Researcher, Chainat Rice Research Center, Chainat Province; and Mr. ChaleawNoiseang, farmer at Preak-Sri-Racha, Chainat Province
Date	**Activities**	**Persons met**
	16:30-19:00 Chainat–NakhonSawan	
25th Apr (Wednesday)	7:30–9:30 NakhonSawan–Phetchabun	
	9:30–13:30 - Visit to farm machine factory/workshop at Phetchabun province - Visit to farmer field at Phetchabun (to learn Dry direct drill seeding)	Mr. ChawalitKhwanyuen, farmer/mechanical worker at Phetchabun province Mr. AmnaogKaknaksing, Agricultural Research Officer (Senior Professional Level), Phetchabun Rice Research Center, Phetchabun province
	13.30-18.30 Phetchabun–Bangkok	
26th Apr (Thursday)	Back to home	

Appendix 2. Members of the Assessment Team

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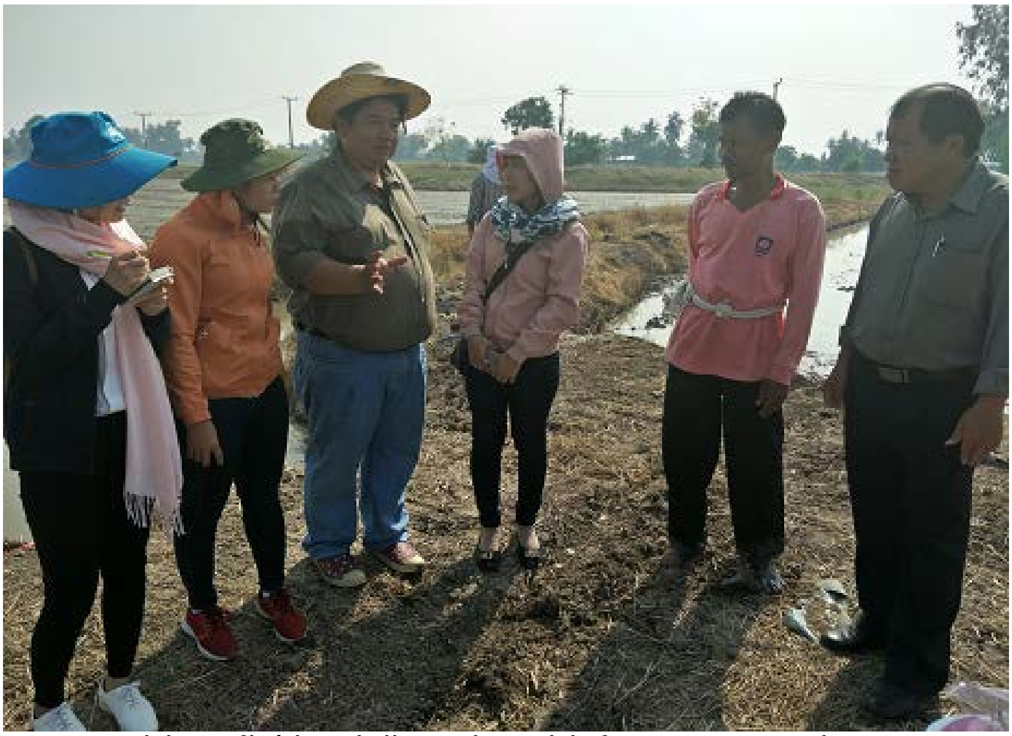
Nguyen ThanhPhuoc (Mr/Dr)	Provincial Sub-Department of Crop Production, SocTrang province	ngthphuocst@gmail.com

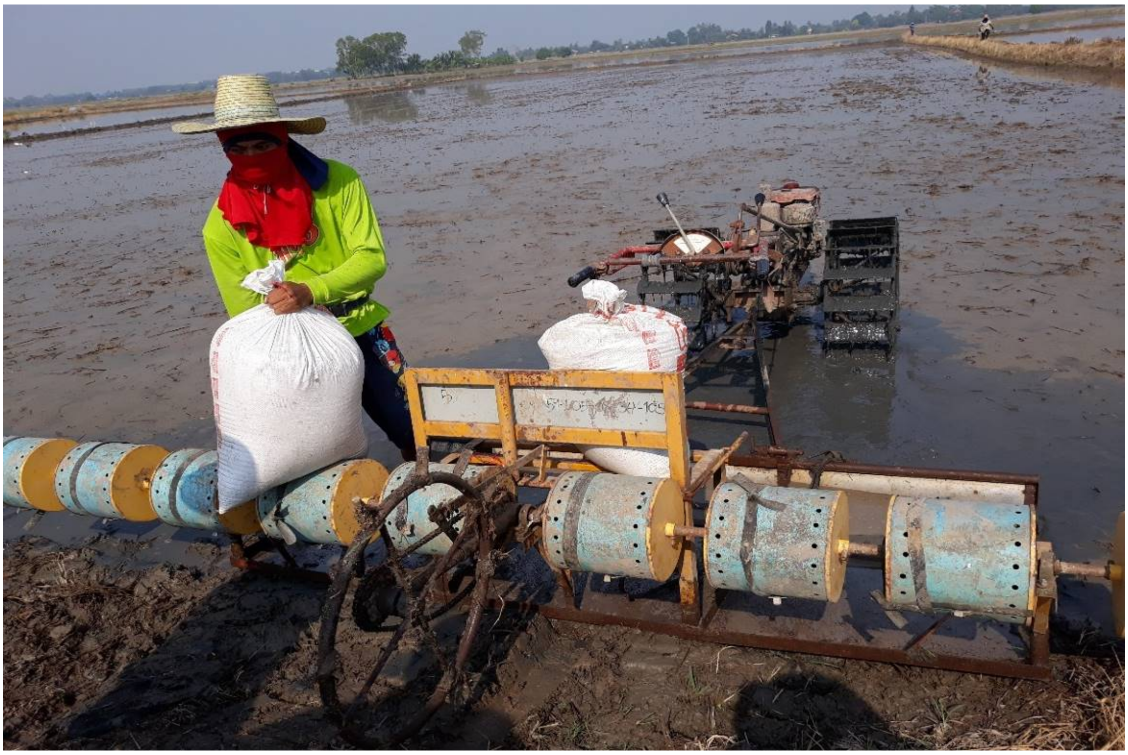
Appendix 3. Photos of the Trip

Visit to Ayutthaya Rice Research Center

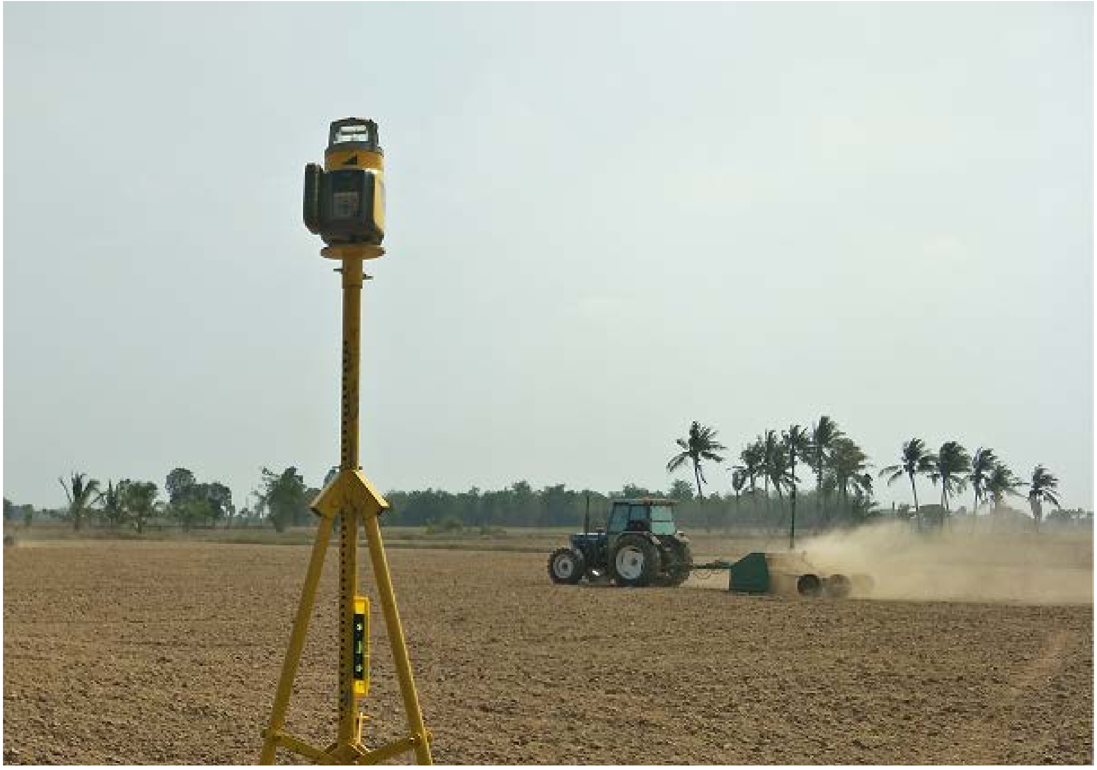

Visit to field and discussing with farmer at Ayutthaya

Visit to farmer field at Ayutthaya

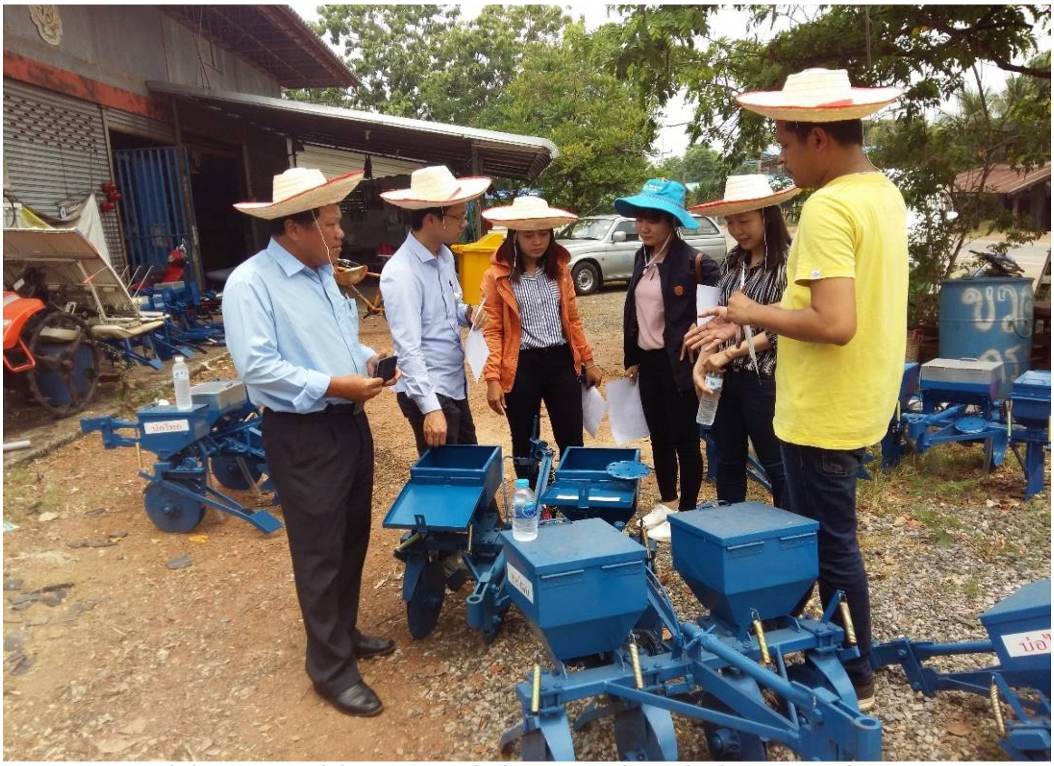
Visit to farmer Thailand Rice Science Institute



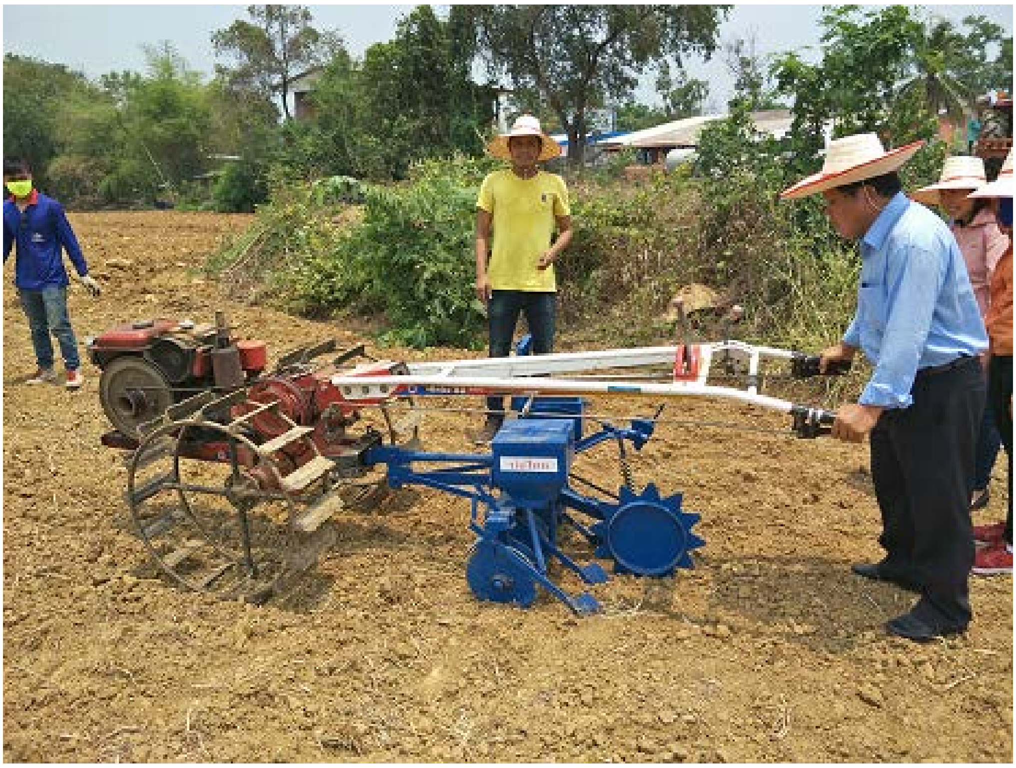
Thailand farmer preparing row seeder in the field at SuphanBuri



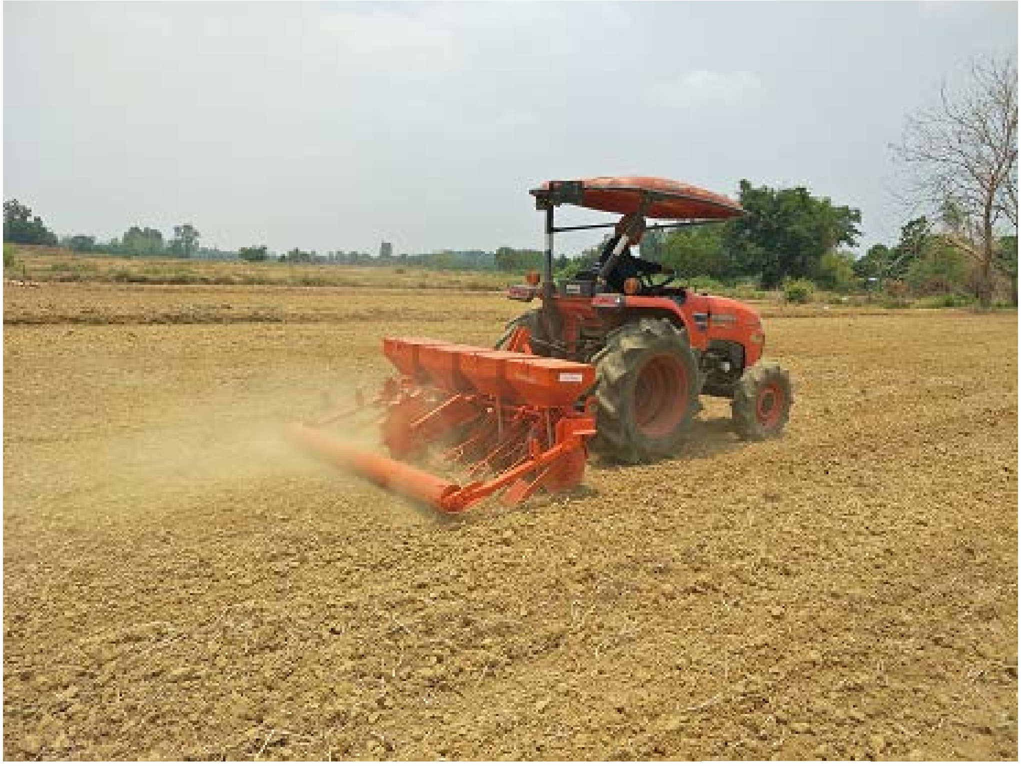
Laser leveling and field preparation for direct seeding at Chainat province



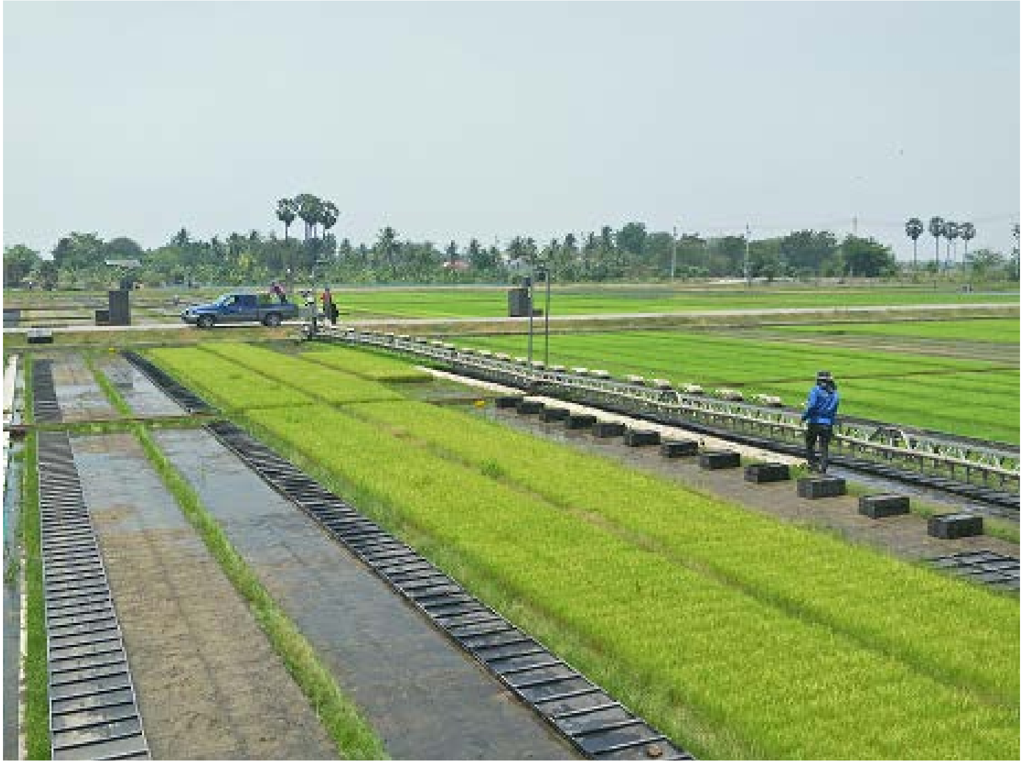
Visit to machinery workshop at Phetchabun province



Testing power tiller-operated seeder (PTOS) at Phetchabun province



Testing power tiller-operated seeder (PTOS) at Phetchabun province



Station of Seed-bed automated production at Mueang SuphanBuri

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