Line-Sown Direct Seed Rice: A Climate Resilient Strategy for Food Security

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Introducing the line-sown DSR method of cultivation is proving to be viable and profitable because it is economical, labour friendly and assures a much greater yield to the farmers of EIP fighting against poverty, malnutrition and starvation

CONTEXT

The East India Plateau (EIP) comprises much of the state of Jharkhand and parts of adjoining West Bengal, Bihar and Orissa. EIP is characterized by high but variable rainfall (1,100–1,600 mm, 80 per cent of which is received from June to September), frequent and sometimes long dry spells within the monsoon, little irrigation, high run-off and soil erosion, infertile soil, terraced mono-cropped paddy lands and subsistence agriculture.

The area suffers low crop yield resulting in food-grain insecurity and endemic poverty. Rice is the staple food crop and the traditional cropping system is mono-crop, rain-fed rice production, which has high climate-related risk and is particularly vulnerable to subtle changes in rainfall distribution, associated with climate change. The pressure of the increasing population has pushed rice cultivation to the medium up-lands, but these lands are not suited for transplanted rice production systems. Cropping in the post-rain season *(rabi)* is limited due to the lack of irrigation resources and uncontrolled grazing by village cattle and goats. The main monsoon crop *(kharif)* is rice (overwhelmingly so for the poorer farmers) and usually very small areas are used for cultivating pulses, oilseeds and maize.

Most villagers achieve only 50–60 per cent of their food-grain requirement, forcing migration in the non-monsoon season to earn some off-farm income at the cost of social upheaval. The outcome of this is widespread malnutrition, limited medical care and low levels of literacy. Perhaps, not surprisingly, the region is a stronghold for left-wing extremist groups.

EIP is one of the poorest regions of India, with a high population of tribal farmers who do not have a long farming tradition. They practice mono-cropping and cultivate crops such as paddy, millet and pulses under rain-fed conditions. The average land-holding per family is less than one hectare and the people cultivate rice mostly in the low-lands and the medium low-lands in scattered plots, which bring down the average size of land-holding to only 0.3 ha per household. Because farming is done under variable rain-fed conditions, the average rice productivity in the region is only 1.96 tonnes per ha.

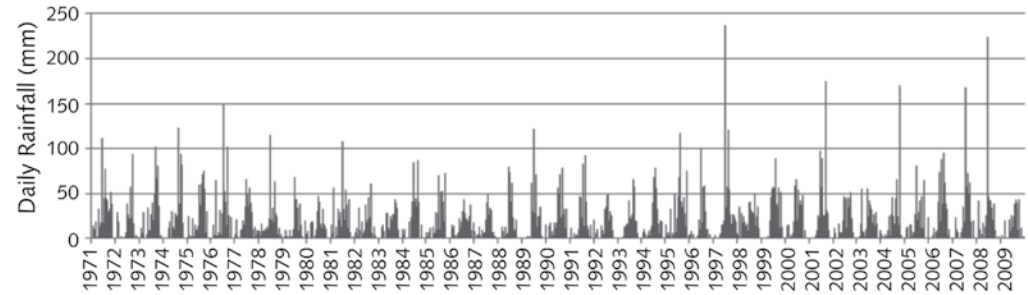
PREVALENT PRACTICES OF PADDY PRODUCTION

Broadcasting and transplantation of rice, mostly in the low-lands and medium low-lands, are very common practices across the EIP, including the Kolhan region of Jharkhand (Kolhan division is one of the five divisions in Jharkhand, comprising three districts, namely, Seraikela Kharsawan, East Singhbhum and West Singhbhum).

The average rainfall in the Kolhan region is about 1,400 mm; however, the pattern of rainfall over the last 40 years shows that rain in the monsoon periods (July to September) is very erratic and uncertain (Figure 1). Because of so much variability and uncertainty, farmers use the traditional broadcasted paddy because this method can withstand dry spells of 10–15 days and it results in some assured yield.

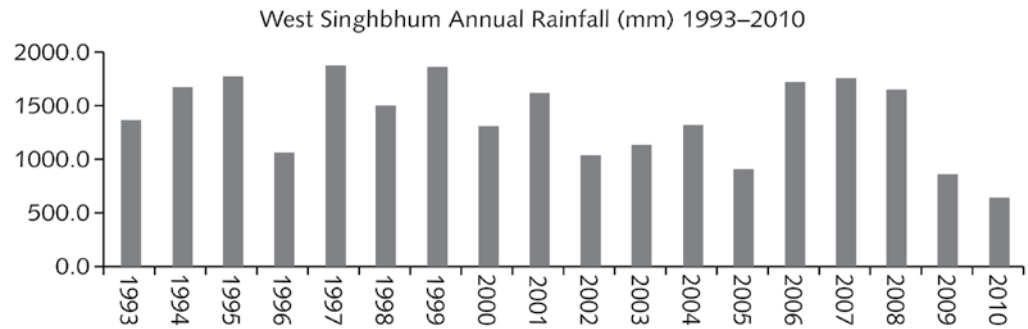
Farmers broadcast paddy seeds in their fields from the beginning of June to mid-July, after one or two showers of rain when the soil is moist enough to be ploughed.

Figure 1: Rainfall Pattern (1971–2009)



Source: Skymet and Indian Meteorological Department (IMD)

Figure 2: Rainfall Pattern (1993–2010)



Source: Skymet and Indian Meteorological Department (IMD)

The traditional broadcasting method of rice cultivation requires a high seed rate (seed rate @ 80–120 kg per ha) and is also very labour intensive. After 45–50 days of broadcasting when the field accumulates standing water, the farmers plough down the standing crop for the thinning and weeding operations (the process is traditionally called *karhan* in the Kolhan region). Half-an-acre of land requires 10–15 labour for weeding and thinning. The remaining weeds are pulled out by hand. These weeding and thinning practices, usually done by women, are very strenuous and involve prolonged working in muddy water, often leading to finger and toe infections.

Because the crop is planted randomly, there is no scope for using any kind of small tools or implements, and the operation of any kind of machine is almost impossible. And because household labour is also limited during this peak period, manual weeding operations become lengthy and delayed, which increases the weed competition and adversely affects the growth of the crop. Even after such an intense operation in the traditional broadcasted paddy, the end yield result is very low—less than one-sixth of the transplanted paddy.

However, because it does not require transplantation or waiting for enough rains to raise nurseries and the puddling of fields, this traditional system of paddy cultivation is much more resilient to the vagaries of the weather and assures the farmers at least some yield. The crop survives in the low or below average rainfall, especially during erratic rainfall, dry spells or poor monsoon.

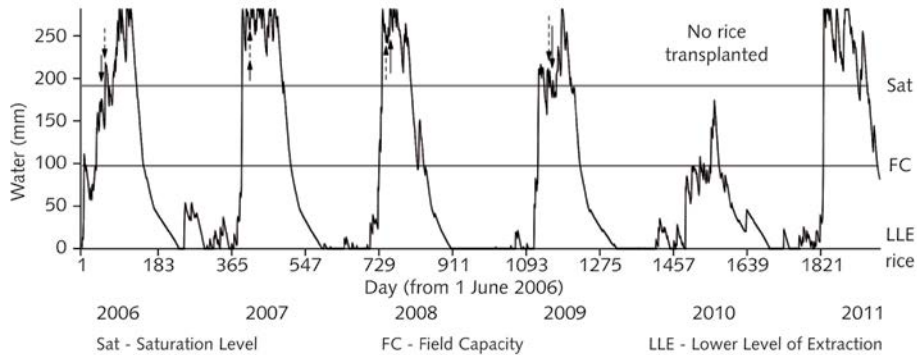
Farmers have adopted transplanted rice practices in some medium up-land and medium low-land areas that have access to irrigation. In traditional rice transplantation, rice is sprouted in a nursery and the sprouted seedlings are then transplanted in standing water; it is dependent, therefore, on assured standing water in the field for puddling (ploughing or harrowing of land with standing water). Seedlings need to be transplanted in time or else they become over-age. Often, however, due to limited irrigation facilities (less than 6–8 per cent of the area is under irrigation) and unpredictable rainfall, the process of transplantation gets delayed.

During the dry spell period, the soil becomes cracked, resulting in the drying-off of paddy in the fields. This is a common feature and is experienced at least every alternate year. The chances, thus, of the paddy crop failing in the transplanted conditions are high. Farmers transplant over-aged seedlings; usually three or four seedlings are used per hill; and the transplantation process stretches until the end of August although the seedlings were raised much earlier (in the beginning of July). Late sowing of long duration (140–150 days) varieties (for example, Swarna Mansuri) results in fewer tillers and small panicle development. The over-mature seedlings quickly go into the flowering stage and these become more pre-disposed to pest attacks. All these factors lead to a low yield.

The harvesting of the transplanted paddy starts by late November or December, by which time the farmers fail to tap the opportunity of using soil residual moisture for the second crop with partial irrigation. Most of the transplanted rice fields then remain fallow for the next six months and the farmers face economic losses and the loss of opportunity for better utilization of resources.

Clearly, in both the methods of rice cultivation, transplanting (which is inherently risky due to climatic variations) or traditional broadcasting (which is labour intensive as well as low yielding) are not very suitable for the farmers in Kolhan or the EIP region. An alternative approach is needed.

Figure 3: Rainfall and Duration of Ponding (2006–11)



RAINFALL AND SOIL MOISTURE

Understanding about soil moisture and rainfall is important because the moisture in the soil determines the planting of crops and their subsequent growth. Rainfall data (2006–11 collected by PRADAN in Purulia) and the corresponding soil moisture conditions in the medium up-lands during the period show that there is huge variation in the ponding duration in the medium up-lands. Ponding of water in the fields is essential to ensure transplantation and further growth of transplanted paddy.

Between 2006 and 2011, the ponding duration varied from 0–106 days (Figure 3). There was no water available for ponding and rice was not transplanted in the medium up-lands in 2010, which was a drought year. Farmers kept waiting for the puddling of soil, and the paddy crop failed, especially the transplanted crop in the medium up-lands.

A critical look at the data of these years reveals that although there was not adequate water for puddling, there was enough water every year for a non-flooded crop to grow. As seen in the Figure 3, there was enough soil moisture between the soil at field capacity (FC) and the saturation level (Sat) in all the years from 2006 to 2011, even in the so-called drought year, 2010. There were possibilities of growing crops that are not dependent on flooding, including the short duration rice of 100–120 days variety, under direct seeding, and vegetables in the medium up-lands.

DIRECT SEEDED RICE

Line-sown direct seeded rice (DSR) is an innovative and modified method (direct seeded broadcasting method) of paddy cultivation, in which sorted and treated seeds of short-to-medium duration are used. Seeds are hand sown in lines made with a 'multi-teeth marker' under dry land conditions at the end of June with a 10″ line-to-line spacing and 6–9″ spacing from seed to seed. This way of sowing rice requires urgent weeding and thinning after 15–20 days of sowing, followed by a second weeding at 25–30 days. Weeding can be done using the 'wheel hoe' in dry-land conditions and the 'cono-weeder' in wet-land conditions. In case of a delayed monsoon, the line-sown DSR crop gets established easily whereas transplanted rice often fails or yields poor results.

Line-sown DSR rice may have huge scope/ advantage in the EIP region by adding value to the traditional method of broadcasting of paddy. It has the potential to produce more yield in transplanted rice (conventional), is at

DSR paddy field matures earlier than a transplanted paddy field. Early harvesting of the crop creates scope for the second crop, using the available residual moisture.

par with the SRI method of rice cultivation, and has many advantages over transplanted and traditional broadcasting methods of paddy cultivation. In DSR, the rice seed is sown and sprouted directly in the field, eliminating the laborious process of planting seedlings by hand and greatly reducing the crop's water requirements. It is resilient to the changes in the climate; with no dependency on the rains for puddling, it involves the least soil disturbance and there are minimal chances of the soil cracking during dry spells. Line-sown DSR can allow a rice crop to be established in seasons when transplanted rice often fails or yields poorly due to late sowing. The additional advantages include:

- Reduced labour requirement (no nursery phase, no puddling or no transplanting)
- No dependence on the onset of monsoon because sowing can be completed in partially dry soil after the pre-monsoon showers
- Effective and efficient weed management, using mechanical weeders, made possible and easy because of line sowing
- Earlier sowing and earlier harvest, creating opportunities for early sowing of a *rabi* crop, and accessing soil residual moisture with partial irrigation if required
- Less quantity of seeds (by 50 per cent) required as compared to broadcasted paddy
- Reduced drudgery for women because there is no nursery, no transplantation and no manual weeding

EXPERIENCE WITH DSR

The experimentation with DSR started in Purulia in 2007–08 under the Australian Centre for International Agricultural Research (ACIAR) project, wherein the attempts were to secure food production for families that only had up-lands, where the paddy crop failed often. In the beginning, we had mixed experiences. Timely weeding and planting are critical for the success of DSR. The average yields were around 4 tonnes per ha; however, ensuring timely weeding was a challenge. Manual weeding with spades or pulling out

Table 1: Yield Comparison in Kalpana Hasda Fields, Talaburu Village, West Singhbhum, 2012

Practices	Area (ha)	Variety	Date of Sowing/ Transplantation	Effective Tillers (Average Three Samples)	Grain Per Panicle	Date of Harvest	Crop Duration	Yield in Actual Area (Kg)	Yield/ Ha (Kg)	Second Crop
DSR	0.06	Abhishek	July 18, 2012	28	254	November 14, 2012	116	384	6,857	Chickpea
Transplanted paddy	0.14	Abhishek	July 30, 2012	DNA*	DNA*	November 18, 2012	133	624	4,333	Fallow
Broadcasted	0.22	Local	June 30, 2012	DNA*	DNA*	July 11, 2012	119	150	670	Fallow
SRI	0.15	Abhishek	DNA	DNA*	DNA*	DNA	DNA*	810	5,506	Fallow

**DNA- data not available*

Table 2: DSR in 2013–14

Participating Farmers	FY	Areas (ha)	Paddy Variety	Yield (kg/ha)*	Land Category	DOS**	DOH***	Rabi Crop
Babli Doraiburu	2013	0.044	Abhishek	5,964	Medium low-land	23 Jun	31 Oct	Tomato, chickpea
Kalpana Hasda	2013	0.051	Abhishek	6,426	Medium low-land	23 Jun	01 Nov	Chickpea
Gurbari Hasda	2013	0.031	Abhishek	5,568	Medium low-land	22 Jun	29 Oct	Green gram
Gita Kunkel	2013	0.114	Abhishek	5,228	Medium low-land	23 Jun	24 Oct	Chickpea
Pelong Kunkel	2013	0.049	Abhishek	5,254	Medium low-land	28 Jun	30 Oct	Chickpea
Sarswati Surin	2013	0.024	Abhishek	5,722	Medium low-land	8 Jul	21 Nov	Chickpea
Average				5,694				

** Converted from dried total field yield; **DOS: Date of Sowing; ***DOH: Date of Harvesting*

Table 3: Labour for Different Operations (in Person Days, PDs) Per Hectare

No.	Name of Farmer	Area (ha)	Practices	Sowing	Nursery management	Transplantation	Karhan	Thinning and Weeding	Total PDs**	Average
1	Kalpana Hasda	0.28	DSR	11.4	NA	NA	NA	15.2	26.5	61.9
2	Gurbari Hasda	0.32	DSR	9.8	NA	NA	NA	63.7	73.5	
3	Babli Doraiburu	0.19	DSR	21.5	NA	NA	NA	40.3	61.8	
4	Gita Kunkel	0.71	DSR	13.2	NA	NA	NA	78.9	92.1	
5	Pelong Kunkel	0.31	DSR	13.6	NA	NA	NA	27.2	40.8	
6	Sarswati Surin	0.15	DSR	31.3	NA	NA	NA	45.1	76.4	
7	Surin Hansda*	0.88	SRI	NA	12.2	95.2	NA	25.0	132.4	115.2
8	Kalpna Hansda*	0.88	SRI	NA	15.8	57.1	NA	25.0	97.9	
9	Colye Hansda*	0.50	Broadcasting	5.0	NA	NA	10	90.0	105.0	105
10	Babali Hansdas*	0.25	Broadcasting	5.0	NA	NA	10	90.0	105.0	

** Interactive data, 1 PD (Person Day) = 6 hours, ** Includes sowing/nursery management, transplantation, weeding, thinning only.*

by hand were cumbersome during the busy monsoon months. The attempt, therefore, was to find some affordable mechanical tools for efficient line planting and weeding.

PRADAN has been working in line-sown DSR in West Singhbhum and Bokaro districts of Jharkhand since 2012, with the support of scientists from the ACIAR, the Asian Vegetable Research and Development Centre (AVRDC) and the Advanced Centre for Water Resources Development and Management (ACWADAM).

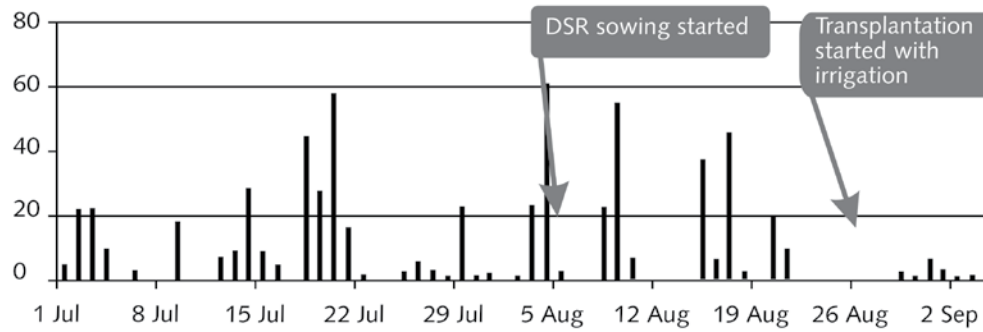
The promotion of line-sown DSR was initiated at the hamlet level with concept seeding in the SHGs, the main focus being on current issues and concerns about the traditional way of broadcasted as well as transplanted—puddled paddy—cultivation and the scope and potential for line-sown DSR in the region. SHG members have been encouraged to try line-sown DSR cultivation on an experimental basis in the beginning to observe the results—the pros and cons—so that in subsequent years, more families may take up the technology.

In 2012, only three famers—Babli Doraiburu, Kalpana Hasda and Guruwari Hasda—participated in line-sown DSR cultivation in their medium low-lands in Talaburu village, Tonto block, West Singhbhum. Babli, Kalpana and Guruwari harvested 5,166 kg, 6,695 kg and 7,813 kg per ha, respectively.

In an experiment, Kalpana cultivated paddy in four adjacent plots applying four different methods, namely, traditional broadcasting, transplanting, DSR and SRI. She used the local variety of 140 days duration in the broadcasting method; for the other three methods, she used the high-yielding Abhishek variety of 120–125 days duration. The yield comparison (as seen in Table 1) was quite significant with DSR showing at par results with SRI paddy. And because the crop was harvested early, the same field was utilized for a second crop.

In 2013, seven new farmers, besides the original three, tried the DSR method in an average area of 0.05 ha. The yield realized in 2013 was quite significant and very exciting for the farmers. The sowing and harvesting were completed by the end of June and October, respectively. Line-sown DSR performed at par even with the SRI crop in the neighbouring field. Due to the late transplantation of the SRI crop and other transplanted rice, harvesting was late and the farmers failed to take advantage of the residual soil moisture

Figure 4: Rainfall (in mm) and Field Operations in DSR and Transplanted Rice in West Singhbhum during *Kharif* 2014



for the second crop. In the line-sown DSR fields, however, they could cultivate a second crop. Yields from two neighbouring traditional broadcasting fields were recorded as 1,812 and 2,370 kg per ha, respectively, as compared to 5,228 and 6,426 kg per ha. The yield from the neighbouring SRI field was 7,123 kg (HYV Lalat, 120 days), which was 11 per cent more than line-sown DSR. Table 2 gives the details of the yield data for the FY 2013–14.

Another remarkable factor is the investment in labour use (Table 3), which was 36 per cent less in line-sown DSR as compared to traditional broadcasting and transplanted rice and even SRI rice (labour considered for this comparison includes sowing/transplantation, weeding and thinning only).

Figure 4 represents the rainfall and field operations in DSR and transplanted rice in *kharif* 2014. That DSR operations start one month earlier than transplantation operations, even before the farmers start raising the nurseries is clear. DSR, therefore, uses the soil moisture more efficiently than transplanted rice in medium low-lands.

UP-SCALING DSR

During the team's review meetings, it was evident that in spite of its intensive intervention in promoting SRI paddy, only 30–40 per cent of the farmers used SRI out of the total plan. The reason was the late and erratic monsoon. Because of the late monsoon, soil puddling does not occur and the seedlings become over-age, etc. Only 10–12 per cent of the farmers in Jharkhand have access to irrigation, used mainly for other crops and mostly for the *rabi* crops. Far better it is, therefore, to facilitate planning for the paddy cultivation after taking into consideration the weather history, rainfall pattern, farmers' interests and irrigation infrastructure in the paddy land.

During the livelihood planning meetings this year (2014), almost 40–50 per cent of the paddy area from the medium up-lands to low-lands have been under traditional broadcasting. Farmers started sowing very early in June or even earlier. Quite late, the team realized that it could have facilitated line-sowing for the community. Although the team planned for 2,000 families, only 729 farmers finally decided to use line-sown DSR. This was mainly due to the team's untimely planning. Farmers had sown seeds after the first showers, with little or no soil moisture. Paddy germinates even with very little or no soil moisture. This was a great learning for the team members, who realized that they had to move with the farmers' time-table so that a greater number of families could adopt the line-sown DSR technology.

SCALING-UP STRATEGY ADOPTED BY THE TEAM

1. Field exposure visits-cum-group discussions were organized among SRI and DSR farmers at the Cluster level.
2. Orientation was held for various stakeholders around this initiative, including the *panchayati raj* institution (PRI) representatives, the Agricultural Technology Management Agency (ATMA) staff, and the tool suppliers/vendors at the Cluster-level *melas* to reach more families.
3. Exposure visits-cum-interactions were held with DSR host farmers in the field from new areas.
4. Field-level guidance and support were sought from experienced farmers and expert service providers for SHG members in new areas.
5. Awareness was created through the introduction of IEC (Information, education and communication) material such as flex boards, leaflets, photographs

Table 4: Details of the Operational Procedure in DSR

Timeline	Major Activities	Remarks
Second to third week of May	◆ Ploughing of field begins after receiving one or two pre-monsoon showers	◆ Easy to plough ◆ Ploughing reduces the clods ◆ Reduces pests and diseases in the coming crops
Beginning of June	◆ Final field preparation with levelling	◆ Field preparation should match with farmers' traditional broadcasting calendar.
Beginning June to mid-July	◆ Major interventions: ◆ Seed sorting and treatment ◆ Marking line using 'litho-markers' ◆ Seed sowing, and covering of seeds ◆ Application of farmyard manure (FYM), *ghana jeevamrutha* at the rate of 75 kg for 30 decimals of land as basal, followed by the same dose during the first weeding and the second weeding, or chemical fertilizers at the rate of N=70, P=42 and K=30 kg per ha in the soil.	◆ Optimum time for sowing depends on receiving 10–15 mm rain ◆ Soil should have 8–15% moisture for better germination, usually after receiving one pre-monsoon rain. ◆ Beginning of June is good for sowing. ◆ Seed rate—6 kg per hectare ◆ Spacing row-to-row of 20–25 cm (9–10") with continuous dropping, or drop two seeds at a distance of 6–9" in the line
By 15–20 days after sowing	◆ Thinning and first weeding operations	◆ Manual thinning and mechanical weeding is done. ◆ Thinning of seedling is done to maintain proper seed-to-seed spacing. Thinning is ensured manually, where the seed is dropped continuously.
July–August	◆ Second weeding mechanically in 1–2" of standing water, application of nutrients (as recommended)	◆ Weeding with the 'cono-weeder'
Late August	◆ Application of nutrients as per recommendation	◆ Based on crop status/growth
October	◆ Harvesting of paddy	◆ For variety of 100–120 days duration
Mid to end-October	◆ Rabi crops (legumes, pulses and other short-duration vegetables)	◆ To utilize residual soil moisture

and videos, to create awareness.

6. Linkages were established with tool fabricators/suppliers, to ensure availability of implements.
7. Mobilization of resources and training of people were organized for SHGs, Clusters and Federations.
8. Focus was on SRI promotion in low-land areas where puddling is more predictable.

IMPLEMENTS ESSENTIAL FOR DSR

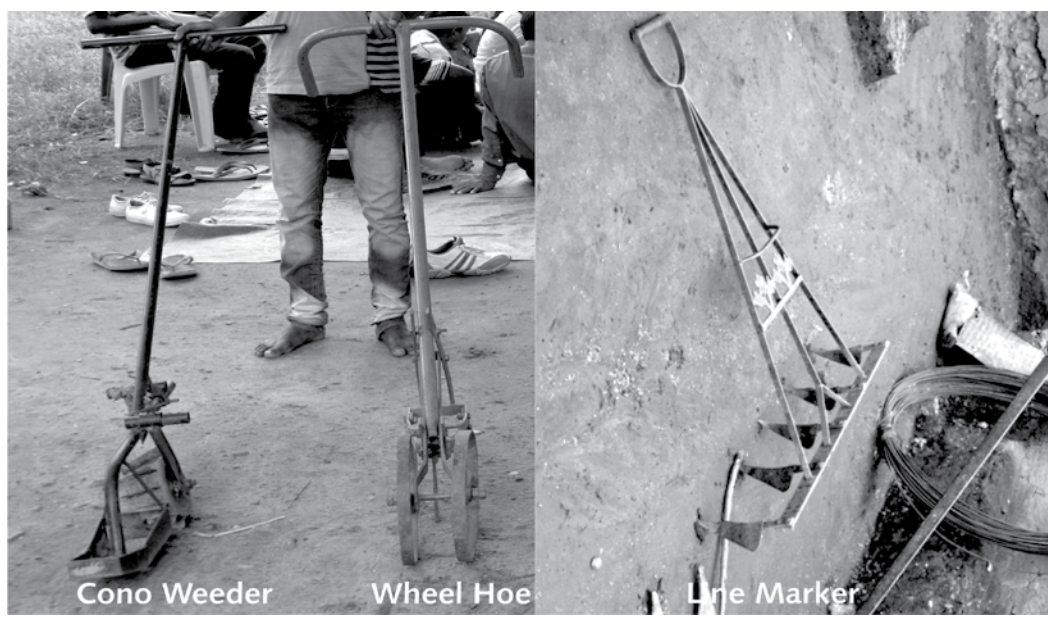
Line marker: This is used for row marking after the final field preparation and levelling, for sowing the seeds in line.

Wheel hoe: This is a three blade hoe, fitted with a wheel and shaft and is used for weeding and loosening the soil, 15–20 days after sowing in dry soil conditions, for young tender weeds. During this operation period, the thinning of seeding is also ensured. It is also used to maintain proper seed-to-seed spacing.

Cono weeder: This tool is used after 25–35 days of sowing in 1–2" of standing water in the paddy field.

LEARNINGS

1. Early sowing and early harvesting help the family overcome the hunger period. The rice arrives at home in October when the reserves at home are near depletion and the new harvest from the transplanted fields is still two months away.
2. Farmers get an opportunity to sow second crops, for example, chickpea, mustard and vegetables, using the residual soil moisture and supplemental irrigation, if required. It leads to better resource utilization, additional crops and income.
3. The use of tools and implements save time, reduce drudgery for women, especially in transplantation and weeding. With the utilization of tools and implements, there is better task-sharing in the family because men and grown-up children like to work with implements.
4. Soil structure improves, leading to better water infiltration and root growth. Puddling practices destroy the soil structure. Soil particles are dispersed, and



when the soil dries, it becomes very hard. It makes ploughing very difficult. DSR practices do not require puddling; the soil, therefore, slowly regains it structure and becomes granular, beneficial for root growth and water infiltration.

CHALLENGES

The challenges with DSR are to ensure affordable quality implements for line-seeding and weeding tools at the community level. Without ensuring the availability of these implements, the success of DSR will be difficult because of the weed load and the need for removal of weeds in time. Another issue is the risk of a wet harvest because sometimes there are storms and significant rainfall in East India during October, which can affect the mature rice crop in the fields or on the threshing floor. Protection of harvested rice may be required in October. Birds and rats also cause damage to the plants, especially when only a few farmers adopt DSR. The few maturing fields in the whole area attract all the birds, rats and squirrels and this may require special measures to ward them off. Once the practice is adopted on a larger scale, the damage from birds and rodents will be reduced significantly. Getting good quality short and medium duration (90–120 days) varieties of seeds too might be a challenge in some of the areas.

If these challenges can be overcome, DSR cultivation will prove more effective because it is a more climate-resilient and predictable method of rice production than transplanted rice in the medium up-lands under rain-fed conditions. At the same time, it is more woman-friendly because the back-breaking tasks of carrying the seedlings, transplantation and pulling out of weeds by hand, mainly done by women, are eliminated. With the introduction of tools and implements, the tasks become easier and are shared by men.

We are very grateful to the women farmers of West Singhbhum, Ramgarh and Purulia districts, who took the risk of experimentation and contributed to our learning. We are also sincerely thankful and acknowledge the contributions of Prof. Peter Cornish from the UWS, who helped us to think through and work with the challenges of agriculture in EIP. We are beneficiaries of his wisdom. All the knowledge, evidence and data presented above are the outcome of the hard work of the whole research team of two ACIAR research projects and we are enormously thankful to them. We are also thankful for the support and guidance provided by the AVRDC and the ACWADAM.