SYSTEM OF RICE INTENSIFICATION –A CASE STUDY FROM BHUTAN

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Executive Summary

This is the first report on the revolutionary technique of planting single rice seedlings, otherwise known as the System of Rice Intensification (SRI), in southeastern Bhutan. SRI has been trialed in two gewogs in 2014 with positive results. SRI out-yielded the conventional method in Pemathang by 28%. Furthermore, in Langchenphu, the incorporation of Dhaincha green manure improved the yield of paddy rice even further. Farmers are taking note of these new trials by conducting their own on-farm trials in 2015. This pilot study has shown that SRI has the potential to increase the average rice yield in Bhutan and improve the livelihoods of small-scale farmers who depend on a successful and abundant harvest.

BACKGROUND

Introduction

System of Rice Intensification (SRI) is a methodology aimed at increasing the yield of rice produced in farming by changing the management of plants, soil, water and nutrients. Some say it is labour intensive,[1] but the potential advantage of using less water than conventional production[2] and it's adaptability as an organic method makes it of interest to many, including the Samdrup Jongkhar Initiative (SJI; http://www.sji.bt/), as it may fulfil one of the main aims to increase organic agricultural production in the region.

The key features of SRI are the recommended use of younger seedlings that are singly transplanted and thinly spaced.[3] SRI is an evolving set of practices, principles, and philosophies. According to the SRI International Network and Resources Center at Cornell University, "SRI is not a recipe of precise things to do." This flexibility in SRI's definition of practices has often rendered SRI a challenge for implementation, evaluation, and assessment of adoption.[4]

SRI was originally developed in the highlands of Madagascar by the French Jesuit missionary, father Henri de Laulanié, who published his results in the journal *Tropicultura* in 1993 (with an English translation published in 2011). He brought together three revolutionary principles: planting single seedlings at the 2 to 3 leaf stage, wide plant spacing, and applying minimal irrigation to keep the soil just at or below saturation. These three essential elements were complemented by general principles of improved rice cultivation that incorporate recommendations for drainage and irrigation, in addition to nursery establishment, careful transplanting, land preparation, weeding, and harvest.[5]

Since its development by de Laulanié, SRI spread outside of Madagascar, and its practices evolved into a suite of flexible principles to be adapted to local conditions rather than into a fixed technological package. SRI has been practiced in 54 rice-growing countries.[6] The success of SRI in similar lowland flooded rice growing areas, such as, Nepal and India, as well as recent success in Bhutan, prompted this pilot impact project in three lowland rice growing gewogs of Samdrup Jongkhar, Bhutan.

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[1] SRI does require more labor - about 26% in one Madagascar evaluation, 11% in a Sri Lankan survey - but depending on the cost of labor, the value of increased production increases the returns to labor by at least 50% and often several hundred percent. Once the methods have been mastered, the labor requirements for SRI decline. Also, implements are being developed that save labor. In Cambodia, over half the farmers using SRI now report that is labor-saving for them.

[2] Since yields can double or more with only half as much water, the productivity of water is greatly increased -- this is especially important in countries or places where water is becoming scarce.

[3] http://en.wikipedia.org/wiki/System_of_Rice_Intensification

[4] http://irri.org/news/hot-topics/system-of-rice-intensification-sri

[5] http://irri.org/news/hot-topics/system-of-rice-intensification-sri

[6] http://irri.org/news/hot-topics/system-of-rice-intensification-sri

Overview of SRI in Bhutan

In 2006, Bhutan became the 28th country to report SRI benefits after Karma Lhendup, then, of the Sherubtse College in eastern Bhutan, showed yield increases over the conventionally practiced method in a set of replicated trials at three locations in Kanglung gewog[7]. Karma Lhendup, together with the College of Natural Resources of the Royal University of Bhutan, and Mahesh Ghimire, of the Renewable Natural Resources Research Centre at Bajo, during 2007 and 2008, showed a further yield improvement with the incorporation of organic matter and soil aeration. Karma Lhendup noted a 31 percent increase in yield using the SRI method (9.6 t/ha) over usual methods (6.6t/ha) at Sopsokhe using the improved rice variety IR64. Karma Lhendup identified the benefits of SRI, as needing fewer seeds and less water and having a shortened crop cycle (by as much as 15 days) and reduced infestation by *Potamogeton distinctus*, a weed that severely affects rice crops in the region.

Growing interest in SRI across Bhutan led to an SRI study tour by researchers and district agricultural officers to India and Nepal in October 2009. During 2009, extension efforts in Deorali gewog have produced encouraging results with farmer yields of 3.5 t/ha, well above the national average of 1 t/ha. In a 2013 article (http://www.theguardian.com/global-development/poverty-matters/2013/feb/11/bhutan-first-wholly-organic-country?INTCMP=SRCH) about Bhutan's plans to go 100% organic, Pema Gyamtsho, Bhutan's Minister of Agriculture and Forests at that time, said that the government has been experimenting with SRI since it has been shown elsewhere to increase crop yields with no synthetic chemicals.[8]

Background on the trials with the Samdrup Jongkhar Initiative (SJI)

SRI is very new to the people of Pemathang, Phuntshothang, and Langchenphu gewogs. The SJI has implemented SRI trials plots in these gewogs, serving as pilot impact areas, as they are predominantly rice-growing areas. The project has been funded by the International Development Research Center (IDRC), of Canada, with a sum of USD $2000 that was divided amongst the gewogs.

Pilot Impact Areas

Phuntshothang

Phuntshothang, traditionally known as Bangtar, is located in southern Samdrup Jongkhar dzongkhag bordering Assam, India (Figure 1). It covers an area of 130.2 km^2 and the total population is 4590. The gewog has a sub-tropical climate, a humid summer (June-September) with heavy rainfall of more than 200 cm, and a cool and dry winter. The altitude ranges from 359-450 meters above sea level (masl). Soil types range from sandy to clay loam

[7] http://sri.ciifad.cornell.edu/countries/bhutan/index.html
[8] http://sri.ciifad.cornell.edu/countries/bhutan/index.html

and are generally recognized as productive for agriculture. The agroecological climate and soil makes this area ideal for paddy rice production. There are 975.61 acres of wet land paddy rice. Paddy is the staple food and cash crop, with ginger, mandarin, and areca nut also contributing to farmer livelihood generation[9].

Pemathang

Pemathang gewog is adjacent to Phuntshothang (Figure 1) with similar climate, soils, and cropping systems. The elevation ranges between 600 to 1200 masl and is described as a hanging plateau of southern foothills above the Assam plain. Paddy rice is cultivated on 976.07 acres.[10]

Langchenphu

Langchenphu gewog is under Jomotshangkha Drungkhag, Samdrup Jongkhar district located nearby northeast of Assam (India) and southwest of Arunachal Pradesh (India) states with altitude ranging from 212-757macl. The geographic size of the gewog is 292.54sq.km. It has warm and wet summer and cold winter. The annual average temperature falls to 17 ^{o}c in winter and 40^{o}c in summer approximately. Annual rain fall ranges from 1500-3500mm. soil type is wide range from mostly sandy loam, clay loam or red soil type, etc and landscape ranges from 60% plain to 30% gentle sloppy arable areas and 10% land under rug terrain and wildlife prone zones. Wet land is 500 acres and 700 acres of dry land approximately.

[9] Phuntshothang Gewog Administration, Samdrup Choeling Dungkhag.
[10] Pemathang Gewog Administration, Samdrup Choeling Drungkhag.

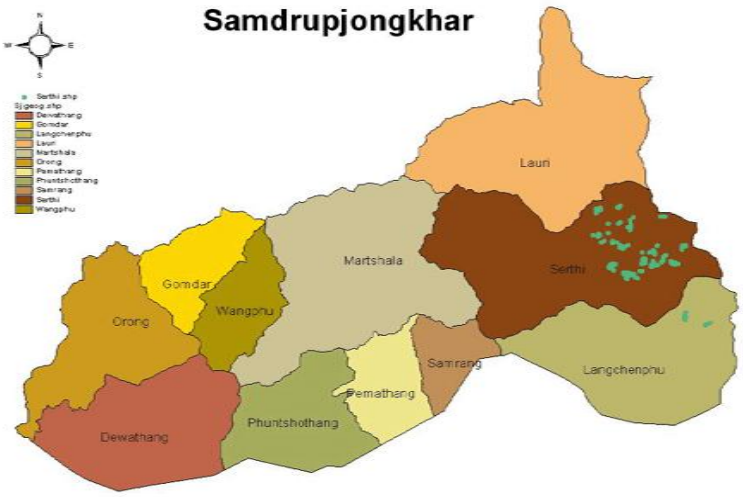

Figure 1. Samdrup Jongkhar dzongkhag and 11 gewogs.

APPROACH

Phutshothang

As good luck does not favor all the time, SRI in Phuntshothang could not take off because the AEO had to attend to other urgent duties offsite. When the AEO returned, the seedlings were crooked because the trays were stacked preventing light from reaching the seedlings. As a result, the SRI trials will be attempted in 2015, according to Choni Lhamo, Agricultural Extension Officer (AEO) of Phuntshothang.

Pemathang

Seed preparation

SRI: The paddy saplings were prepared on 12 July, 2014 at Mr. D.C.Wakhley's, a local farmer's, house. The variety of paddy used was the high yielding IR7915195-42-1-3-1, locally named as Zhung Khamti. The seeds were first soaked in water for three days. 35 trays were seeded (Figure 2) and after eight days (second leaf stage) these were transplanted.

Conventional: Seeds were broadcasted in early June into a nursery bed following normal practices.

Figure 2. Seedling tray for SRI

Transplanting seedlings

32 people gathered at D. C. Wakhley and Sangay Wangdi's

paddy fields, of which 21 of them were women.

SRI: Transplantation was done on 22nd of July, 2014. It was advised by the AEO that the transplanting of single seedlings (Figure 3), instead of clumps of several seedlings, should be done quickly, within 30 minutes after the seedlings are removed from the nursery. Care is needed to keep soil and seed attached to the root, putting the roots into the soil at a very shallow depth (1-2 cm), without inverting the root tips by pushing them straight down into the soil (Figure 4). If not done this way, there is a chance that seedling growth would be disrupted. Careful handling of seedlings prevented desiccation and trauma to the roots, with little or no interruption to plant growth, as well as helping to prevent 'transplant shock'.

When transplanting, farmers were told by the AEO to plant seedlings in a straight row and column with seedling spaced 20 to 25 cm apart. The planting was completed in two hours. "We are worried how this method could yield more since we are planting single plants", murmured almost all the farmers.

Conventional: Transplantation was done on 1 July, 2014 following normal practices. Month old paddy seedlings were uprooted from the nursery bed and transplanted in 3 to 4 seedling clumps of approximately 10 to 15 cm in height.

Figure 3. Dividing seedlings for SRI

Crop rotation and soil fertility– In Pemathang, prior to transplanting, onion was cultivated and Dhaincha (*Sesbania bispinosa*), a local green manure, was incorporated to fertilize the soil. A common recommendation for SRI is to enrich the soil with organic matter to improve soil structure, nutrients, and water holding capacity, as well as soil microbiology. Organic matter represents the base fertilization for the crop and is complemented, if needed, by chemical fertilizer[11]. The only fertilization used for this trial was Dhaincha.

Water – The field was filled with rainwater the day of transplantation, as it was raining over night. Water was drained out first before the soil was tilled with a rototiller to prepare the soil for transplantation. For SRI it is recommended that only a 1-2 cm layer of water is applied during the vegetative growth period, letting the plot dry until cracks become visible [11]. During flowering, a thin

Figure 4. Transplanting SRI in the foreground and transplanted conventional paddy in the background.

[11] http://ciifad.cornell.edu/sri/methods.html

layer of water is maintained, followed by alternate wetting and drying during the grain filling period, before draining the paddy 2-3 weeks before harvest.

For this trial there were two plots, located in the same irrigation channel. During the first 2 months after transplanting the soil was only irrigated when dry and weeded as necessary. Due to fatigue, both farmers utilized frequent flooding to control weeds thereafter, flooding with a ~6 cm layer of water 4 to 5 times a month until flowering when water was withheld.

Figure 5. Conventional paddy on the right and SRI plot on the left.

One month review: 22 August, 2014

Exactly one month after the transplantation of single seedlings, SRI plots were developmentally delayed, possibly because the conventional plots were transplanted (seven days prior) or sown (21 days prior) earlier (Figure 5).

"In my SRI plot, plants are not growing equally. We have planted single plants and the ones that were strong have grown well, but those that are weak are growing slowly. When some plant dies, it creates a huge space, so I personally feel it would be better if we could plant two paddy seedlings in place of one", said farmer Sangay Wangdi.

"As comparing to non SRI, my SRI plot is young and delayed", said D.C. Walkely.

"All these worries you all have on the SRI method are because you are doing it for the first time. I have experience with it, gained during my college training, I am sure each bunch of paddy will yield not less than 7 kg", said Wangchuk, AEO of Pemathang, to motivate the farmers.

Second month review: 25 September, 2014

Tillering was comparable between SRI and conventional plots with a minimum of 16 tillers per plant. The height between both SRI and non-SRI seedlings was similar, however, the leaf color was dark green in SRI plots and became yellowish in conventional plots (see cover photo). Furthermore, the rooting system of SRI appeared stronger than for non-SRI trial plots (Figure 6).

"I was told to not keep standing water in my field, however, weeds are growing wildly, so I do keep it, but not too much, however, now I am happy with my SRI paddy. I am proud to introduce this system in my field", said D.C Wakley.

Figure 6. Left: root system of plant from conventional plot; Right: root system of plant from SRI plot.

Harvesting

On 27 November the conventional plots were harvested and the SRI plots were harvested on 2 December. The officials from Pemathang gewog, SJI, and the farmers of Pemathang were present in the field to witness the harvesting of SRI paddy. All participated in cutting the crop in three different areas that were randomly selected from both SRI and non-SRI trials on one farm site. They were named Sample 1, Sample 2, and Sample 3. Plants were harvested from sample areas that were 6 m^2 each (Figure 7).

Figure 7. Taking samples for estimating yield.

RESULTS

The results of three different samples from SRI and non-SRI trials:

Sample	SRI (kg)	Non-SRI (kg)
1	4.5	3
2	4.5	3
3	3.5	3

Summary of results

From the 6 m^2 area, an average yield of 4.16 kg (2808 kg/ac) was noted in the SRI plot, while non-SRI yielded 3 kg (2025kg/ac). Although this was lower than the AEO expected, the yield of SRI was consistently more than the non-SRI plots.

Langchenphu

There were four farmers who trialed SRI with or without a green manure of Dhaincha. They were Bakta Bahadur Subba, Birkha Bahadur Powdyel, Tshering Tobgay, and Bhim Bahadur. Bhattarai. Each farmer's techniques are outlined below along with the recommendations of Sonam Dorji, the AEO of Langchenphu. SJI farmer liaisons could not monitor implementation because of time limitations.

Seed preparation

Sonam Dorji informed the farmers to, "pre-soak seed in water for 24 hours and incubate in rags for 24 hours before sowing in a well drained soil either in open of polyhouse nursery as this will help seeds germinate faster. Line or random sowing seeds in a tray or open field could be done as per resources availability and convenience".

Transplanting seedling

Transplanting of seedlings was recommended at the 2 – 3 leave stage, without removing soil from the roots. Single seedlings were transplanted at a very young stage and at a shallow depth (2-3 cm), in a slightly slanting position into a well-puddled and leveled field that was not flooded. A spacing of about 25 X 25cm between seedlings was recommended by using a marked rope or pole to get uniform distance. Sonam Dorji informed farmers, "uniform distance can save on seeds required, but also reduces the competition for nutrients, water, and sunlight. Uniform space provides plenty of space for roots to spread out, resulting in a large number of tillers, which correlates to greater yield and facilitates cultural practices like easier weeding and applying manure".

After transplanting, the field was kept moist but not flooded for at least 12 – 14 days. This was followed by alternative wetting and drying (AWD) until the flowering stage. After

flowering, a water level of 3-5 cm was maintained until 2 weeks prior to harvest continuing with the AWD method.

Sonam Dorji informed farmers, "SRI commands a series of wetting and drying cycles until the end of the vegetative stage. When flooded, plant roots die due to lack of oxygen, therefore, it is vital to drain the field and to let the soil dry out until surface cracking. The wetting and drying process allows the plant roots to grow well by accessing both adequate water and air. This saves water and reduces nutrient leaching compared to continuous flooding".

Weeding

Only one manual hand weeding was done at about 12 – 14 days after transplanting.

Soil fertility

Dhaincha (Figure 8) was incorporated as a green manure or not, depending on a test plot prior to SRI transplantation. No chemical fertilizers were used in this trial, but some had farmyard manure (FYM).

Figure 8. Dhaincha green manure.

Harvesting and results (data recording form for SRI trial)

At all the five trial locations three 6 m^2 samples were taken to calculate the average yield of SRI with a Dhaincha green manure and SRI without Dhaincha green manure.

1. Chewog(village): Langchenphutoed
2. Altitude: 340 masl
3. Farmer's name: Bakta Bahdur Subba
4. Sowing date: 14/7/2014

5. Transplanting date: 25/7/2014
6. Area: 0.15 acres
7. FYM: only tethering of cattle in the field
8. Green manure: Dhaincha green manure
    I. Sowing date: 5/6/2014
    II. Incorporate date: 18/7/2014

Variety	Harvest date	Crop cut sample	Crop cut grain yield kg/plot	Moisture content (Mc %)	Grain yield t/ha	Grain yield t/acre
Dhaincha: Moshino (local)	19/11/2014	Sample 1	2.1	16		
		Sample 2	1.9	16		
		Sample 3	2.0	16		
Mean			**2**	**16**	**3.2**	**1.29**
Control: Moshino (local)	19/11/2014	Sample 1	1.1	16		
		Sample 2	1.5	16		
		Sample 3	1.3	16		
Mean			**1.2**	**16**	**1.94**	**0.78**

1. Village: Langchenphutoed
2. Altitude: 338 masl
3. Farmer's name: Tshering Tobgay
4. Sowing date: 5/8/2014
5. Transplanting date: 16/8/2014
6. Area: 0.05 acres
7. FYM: not done
8. Green manure: Dhaincha green manure
    I. Sowing date: 15/6/2014
    II. Incorporate date: 5/8/2014

Variety	Harvest date	Crop cut sample	Crop cut grain yield kg/plot	Mc%	Grain yield t/ha	Grain yield t/acre
Dhaincha: Bhur Kambja ll (improved)	25/11/2014	Sample 1	3.2	16		
		Sample 2	3.1	16		
		Sample 3	3.0	16		
Mean			**3.1**	**16**	**4.98**	**1.99**
Contol: Bhur Kambja ll (improved)	25/11/2014	Sample 1	2.5	17		
		Sample 2	2.8	17		

		Sample 3	2.7	17		
Mean			**2.66**	**17**	**4.25**	**1.70**

1. Village: Langchenphutoed
2. Altitude: 340 masl
3. Farmer's name: Bhim Bahadur Bhattarai
4. Sowing date: 5/8/2014
5. Transplanting date: 16/8/2014
6. Area: 0.15 acres
7. FYM: not done
8. Green manure: Dhaincha green manure
    l. Sowing date: 10/5/2014
    ll. Incorporate date: 7/8/2014

Variety	Harvest date	Crop cut sample	Crop cut grain yield kg/plot	Mc%	Grain yield t/ha	Grain yield t/acre
Dhaincha: Bhur Kambja ll (improved)	19/11/2014	Sample 1	3.4	16		
		Sample 2	3.2	16		
		Sample 3	3.0	16		
Mean			**5.17**	**16**	**5.17**	**2.06**
Control: Bhur Kambja ll (improved)	19/11/2014	Sample 1	3.0	16		
		Sample 2	2.8	16		
		Sample 3	2.6	16		
Mean			**4.52**	**16**	**4.52**	**1.80**

1. Village: Langchenphutoed
2. Altitude: 337 masl
3. Farmer's name: Birkha Bahadur Powdyel
4. Sowing date: 3/8/2014
5. Transplanting date: 12/8/2014
6. Area: 0.10 acres
7. FYM: applied
8. Green manure: Dhaincha green manure
    l. Sowing date: 27/5/2014
    ll. Incorporate date: 5/7/2014

Variety	Harvest	Crop cut	Crop cut	Mc%	Grain	Grain

	date	sample	grain yield kg/plot		yield t/ha	yield t/acre
Dhaincha: Bhur Kambja l (improved)	20/11/2014	Sample 1	3.5	16		
		Sample 2	3.6	16		
		Sample 3	3.3	16		
Mean			**3.46**	**16**	**5.60**	**2.24**
Control: Bhur Kambja l (Improved)	20/11/2014	Sample 1	2.4	16		
		Sample 2	2.8	16		
		Sample 3	3.0	16		
Mean			**2.73**	**16**	**4.41**	**1.76**

The local Moshino[12] variety, although lower yielding than the improved Bhur Kambja II, showed the highest gain in yield due to Dhaincha green manure; 3.2 vs. 1.94 t/ha. Bhur Kambja II with Dhaincha had an average (across farmer) yield of 5.25 t/ha and 4.4 t/ha without. Differences in whether or not FYM was added may have had some effect on the yield but it appears that it was minor. Additional studies would be necessary to validate this claim.

SRI appears to be a valuable technology for increasing the yield of both the Moshino and Bhur Kambja II varieties of rice in Lanchenphu. The AEO mentioned that the higher yield of SRI plots with green manure was likely the result of a higher number of tillers per hill, due to better soil fertility.

LESSON LEARNED

Phuntshothang

Challenges

- Untimely monitoring: The seedlings were not monitored which led to failure of SRI.

Recommendations

- Directly sow into nursery beds to allow greater flexibility in transplanting and reduce day-to-day maintenance.

Pemathang

Benefits

[12] Moshino is a local rice landrace named by southern Bhutanese meaning small and oval. The variety is lower yielding than modern or improved varieties distributed by the government, but it is typically twice the value (Nu. 60 vs. 30 Nu/kg).

Rotatory weeders. Credit to Karma Lhendup

- Require less seeds per acre: Transplants are single seedlings, instead of a clump of several seedlings and seedlings are spaced wider than conventionally.
- More production per unit area: Seedlings are transplanted in good spacing so they access better nutrients resulting in higher tillering and yield.
- Deep and strong rooting system: SRI allows for greater root growth; roots have greater access to nutrients from deeper layers of the soil.

Challenges

- Labour intensive: The transplantation was done manually and took more effort than the traditional method.
- Difficult to reduce overall water use: Due to weed pressure, conventional flooding was necessary.

Recommendations

- Rotary weeders are an effective tool used for SRI and have been successfully utilized in Bhutan. They are promoted in Karma Lhendup's extension manual on the subject. Providing access to these tools will reduce the need for flooding to control weeds.

Langchenphu

Benefits

- Higher production: Spaced transplants lead to better nutrient uptake and higher yield.
- Better grain quality: Grain quality is better comparing to conventional.

Challenges

- Labour intensive: The transplantation of paddy is done manually which requires more labour.
- Pests: Caseworm incidence during the first month after transplant is a potential issue.

Recommendations

- Biocontrol of caseworm

POTENTIAL FOR ECONOMIC DIVERSIFICATION AND UPSCALING

Phuntshothang, Pemathang, and Langchenphu all share similar agroecological conditions making these primary areas of rice production in Samdrup Jongkhar. In these gewogs, most people's livelihoods depend on paddy cultivation, both for home consumption and revenue from trade. Therefore, efforts to improve sustainable production have direct impacts on people's incomes and wellbeing.

In Bhutan, demand for local Bhutanese rice exceeds supply. This has created a demand for local rice resulting in a much higher price (30-35 Nu/kg farm gate) than a comparable Indian import (~25 Nu/kg retail). In 2005, there were 4,205 acres of rice grown in Samdrup Jongkhar. The average yield was 930 kg/ac, close to the average yield for rice across Bhutan of 1082 kg/ac. Technologies such as SRI should be sought to improve the yield of Bhutanese rice to meet local demand. In the two trials successfully conducted, it was found that the yield of rice in Pemathang was much higher than these averages. In Langchenphu they approached the national average, but since SRI was not compared with conventional paddy it would be difficult to draw any conclusion on the effectiveness of SRI over the conventional practices. However, based on these preliminary findings along with previous studies, SRI has the potential to increase the yield of rice in Samdrup Jongkhar warranting further multi-location trials.

To achieve broad scale adoption there are many issues brought up throughout this research that needs to be resolved. These include:

- Improvements in water control required: Small amounts of irrigation water are needed to maintain soil moisture without saturation in SRI, rather than the conventional practice of flooding fields continuously. Farmers who do not have such control or reliable access to water will get less or little benefit from SRI practice. Current irrigation schemes are generally limited in their accuracy of water application and drainage depending on rainfall.
- Weed control: Cultivation devices such as rotary weeders are needed to reduce the reliance on flooding.
- Time: A common complaint of SRI is not higher yield, but the greater time expenditure to achieve those yields. Very little differs between the SRI and conventional systems, but farmers have difficulties securing sufficient labour

during transplanting and weeding. For example, it was possible to transplant ~ half an acre with 15 farmers in 2 hr, but this would take at least two days for one farmer.

RECOMMENDATIONS AND GENERAL CONCLUSION

"The SRI is very good method of planting fewer paddy saplings and gives more yield. This system is relevant to those who own less land", said D. C Wakhley. "I transplanted the SRI paddy right after harvesting onion, I even didn't add any manure, and even then the SRI yield was more than my normal paddy. I will incorporate Dhaincha during the next season, so that it will yield even more than present", said Sangay Wangdi. Similar comments were made by the farmers of Langchenphu. Based on direct comments from farmers it appears that they saw the benefits of planting single seedlings following the prescribed SRI practices.

In these cases, SRI was not viewed as a drastic change in farmer practices, although this was their first experience with SRI. Without intervention these farmers are expected to continue and adapt the suite of SRI practices to their localized context possibly replacing the conventional model. This would be acceptable if the new SRI system was indeed better than normal system, i.e., with less seed, less water, and higher production.

Some recommendation the farmers had for the AEOs:

- All the farmers who practiced SRI in Pemathang and Langchenphu said they would like to continue with next season's trials.
- There was an interest to have an organic alternative to the herbicides that were discontinued.
- Farmers in Pemathang and Langchenphu are asking for Dhaincha seeds as they have seen the positive effects of using this green manure.

Some recommendations the AEOs had for the farmers and the SJI included:

- Care should be taken to transplant in a straight line with equal distance maintained.
- Pemathang requested that rotary weeders and a biocontrol for case worm be made available to farmers.
- No additional help was requested from Langchenphu AEO.

Some recommendations the SJI has for the AEOs:

- Conduct side-by-side trials of conventional and SRI, including additional local and improved varieties. These agronomic trials should also look into the effect of spacing as different varieties may respond to different densities.

- Multi-location trials in farmers' fields will be the most effective method for enhancing the rate of adoption. Farmers with small land holding should be approached, since SRI is best suited for small-scale operations.
- The effects of green manure application should be conducted over multiple seasons, since the benefits will increase over time.
- Farmers need access to appropriate cultivation tools and irrigation and drainage technologies to capitalize on the full potential of SRI.

Bhutan is a mountainous country and has little flat land to cultivate paddy rice. SRI is one solution to produce more rice from less land. In addition, higher production did not come at the cost of synthetic/artificial inputs. Because SRI can reduce the demand for agrochemical inputs, it has a lower ecological footprint than high-input farming systems. By raising the agronomic and economic productivity of land, it enables farmers to produce more with less, justifying the need for increased labour. Producing more output with less input helps bolster sustainability initiatives as well as increase economic returns for farmers.