The system of rice intensification (SRI) for super-high yields of rice in Sichuan Basin

Jiaguo Zheng, Xianjun Lu, Xinlu Jiang, and Yonglu Tang

Crop Research Institute, Sichuan Academy of Agricultural Sciences, Chengdu, Sichuan, China 610066, Email: zhjguo@mail.sc.cninfo.net

Abstract

The System of Rice Intensification (SRI) is a new technique for rice culture. The main features of this system are: transplanting of young seedlings singly in a square pattern with wide spacing, using organic fertilizers and hand weeding, and keeping the paddy soil moist during the vegetative growth phase. Significant phenotypic changes occur in plant structure and function and in yield and yield components under SRI cultivation. The production increases can be notable. However, there are some constraints to adoption of the presently recommended set of practices, e.g., a small number of plants may not be suitable for the low solar radiation condition. Experiments over 2 years are reported in which SRI is modified according to the agro-ecological conditions in Sichuan, with variations in the transplanting pattern, plant leaf-age and density, etc. The following modifications were tested: transplanting 3 separated seedlings in one hill in a triangular pattern with the leaf age extended to 3-4; application of herbicide before transplanting; mulching the spaces between plants with straw; adding chemical fertilizers to promote plant growth vigorously when needed; making shallow furrows before transplanting in the zero-till fields, and applying the alternate-wetting-and-drying method for water management with mid-season drainage to inhibit tillering. With these modifications, grain yield exceeded 12 t/ha, 46% greater than in control using field comparison.

Media summary

The improved SRI and super-high yield (12 t/ha) of rice in Sichuan.

Keyword

Oblong and triangular transplanting pattern, tray nursery, adoption, tillering

Introduction

To assure food security in the rice-consuming countries of the world, those countries will have to produce 50% more rice with improved quality to meet consumers' demand by 2025. This additional rice will have to be produced on less land with less water, less labor, and fewer chemicals. The task becomes even more difficult when rice quality preferences gradually receive more attention. Crop improvement and management have played an important role in increasing the production of major food crops in the past. There is no doubt that the task of making gains becomes even more difficult when rice yield is already at the high level. The System of Rice Intensification (SRI), developed in Madagascar over a 20-year period and synthesized in the early 1980s (Stoop et al 2002; Uphoff et al 2002), offers opportunities to researchers and farmers to expand their understanding of potentials already existing in the rice genome. Experience with SRI methods suggests that average rice yields can be about double the present world average without requiring a change in cultivar's or the use of purchased input (Wang et al 2002). Moreover, only about half as much water per season is required for these higher yields. Crop protection requirements are reduced because SRI plants are more resistant to damage by pests and diseases. The SRI methodology for raising rice production makes three main changes in irrigated rice cultivation: transplanting younger seedlings, preferably 8-15 days old before the plants enter their fourth phyllochron of growth, planting the seedlings singly rather than in clumps of 3-6 plants, and keeping the paddy soil moist but not continuously saturated during the plants' vegetative growth phase. To achieve a super high yield, we introduced the SRI to China rice production in 2000. This paper is the review of research progress on SRI in Sichuan ecosystem.

Materials and method

Four experiments and a fired demonstration were conducted in Chengdu plain, Sichuan province from 2001 to 2003. The varieties used in experiments and field demonstration were hybrid rice, such as Gangyou22, Ⅱyou7, and Chuan xiangyou 2. Experiment 1 compared the original SRI (15 d seedling, 40?40cm, single seedling) and the local technique (CK, 50 d seedling, 30cm?15cm, 1seedling with 6 tillers). Experiment 2 was a modified SRI experiment designed according to the agro-ecological conditions of Sichuan. Experiment 3 involved transplanting rice seedlings (15d) with different densities, i.e., 40cm?40cm, 40cm?45cm, 45cm?45cm, 45cm?50cm, 50cm?50cm, and 55cm?55cm. Experiment 4 involved transplanting with different planting patterns, i.e., CK (50 d seedling, 30cm?15cm, 1 seedling with 6 tillers), SRI (15 d seedling, 40cm?40cm, single seedling), S+3 = square with 3 seedlings(15 d seedling, 40cm?40cm, 3 seedlings per hill), S+T = square with triangle (15 d seedling, 40cm?40cm, transplanting 3 seedling separated as 7 cm triangle per hill), O+T = oblong with triangle (15 d seedling, 40cm?45cm, transplanting 3 seedlings separated as 7 cm triangle per hill). Field demonstration was on modified SRI in large scale at different experiment sites.

Results and discussion

1.Preliminary evaluation of SRI

1.1 SRI is a promising way to increase rice yield. The average hybrid rice yield with farmers' practice resulted in grain yield of about 8.5 t/ha in Sichuan. When the SRI methods were first introduced, rice yield was increased by 20%, and with the modified method (oblong and triangle) intended to suite Sichuan conditions, the increase was still higher, at about 55% (Table 1).

Table 1. Yield response to different planting patterns in rice (2002 Guanghan)

Transplanting pattern	Yield (t/ha)	Compared to CK	
		+ t/ha	+ %
CK	8.65		
SRI	10.42	1.77	20.4
Oblong and triangle	13.39	4.74	54.8

1.2 SRI promotes more vigorous growth of the rice plant

With SRI, leaf blades become bigger, especially for the functional leaves (Table 2). The plant height and culm length become longer (data not shown). The stem diameter of the 4th internode (from top) is 0.49 cm for SRI, 12% more than the CK, hence, results into the very strong stem (data not shown). Leaf area index (LAI) is also much higher for SRI than CK (data not shown).

Table 2. Leaf blade size (cm) response to SRI *(*experiment 1, 2002 Guanghan*)*

Planting pattern	3rd leaf	2nd leaf	Flag leaf	Average

	Length	Width	Length	Width	Length	Width	Length	Width
SRI	64.25	1.57	71.32	1.87	57.67	2.17	64.41	1.87
CK	56.07	1.43	62.03	1.57	48.67	2.01	55.56	1.67

1.3 SRI gives higher output with fewer purchased input, but requires more manual work.

SRI plants have less insect and disease problems and reduce seed requirements by 50-90%. There is a saving of water, as much as by 50%, with high WUE. However, it requires good and careful land leveling to facilitate good water control and minimal application. Also, more time is needed for weeding (data not shown).

1.4 Limiting factors for adoption

1.4.1 The number of foundation plants, being less, appears not suitable in an ecosystem with the low solar radiation of Sichuan. Single plants in a square pattern with wide spacing cannot produce sufficient panicles and the consequent yield potential is limited, as farmers want to maximize the number of panicles/m^2, not panicles/plant. The triangular and oblong planting method appears to be a valuable adaptation of SRI practice, increasing plant density by 50% while maintaining the good plant exposure to the sun and air.

1.4.2 It is hard to transplant young seedlings at 2-leaf age in multiple cropping system. Traditionally older-age seedlings (about 7-leaf stage) are transplanted into fields after wheat harvest. If very young rice seedlings are used, the sowing date has to be postponed which leads some unexpected results such as late maturity, less yield, and difficulties in field management.

1.4.3 Organic fertilizers are often in short supply. Because of the popularity of reduced or zero- tillage livestock population is now decreasing in the rural areas. Hence, farmers now cannot get enough organic fertilizer.

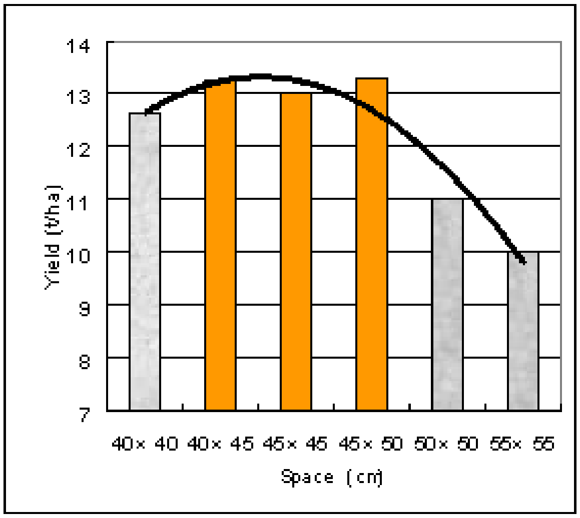
1.4.4 Management measures such as precise weeding and keeping the soil moist are too complex, requiring more labor with SRI.

2.Improved SRI method and its practice in Sichuan

2.1 Using tray nursery to raise seedlings. The seedling nursery is operated under upland conditions, with root system not traumatized during transplanting. With SRI methods, seedlings are removed carefully from the nursery, and are transported to, and placed gently in, the main field within 15-30 minutes. This avoids a long recovering time and the leaf age can be extended to 3-4.

2.2 Transplanting density. The yield is different for the various planting geometries (Fig.1). The best transplanting density is 5-5.5 hills /㎡.

2.3 Oblong with triangle transplanting pattern. Transplanting of 3 separated seedlings from one hill at triangular pattern produces more panicles/m^2 and greater panicle size, giving more 'edge effect' in the main field (Fig.2).



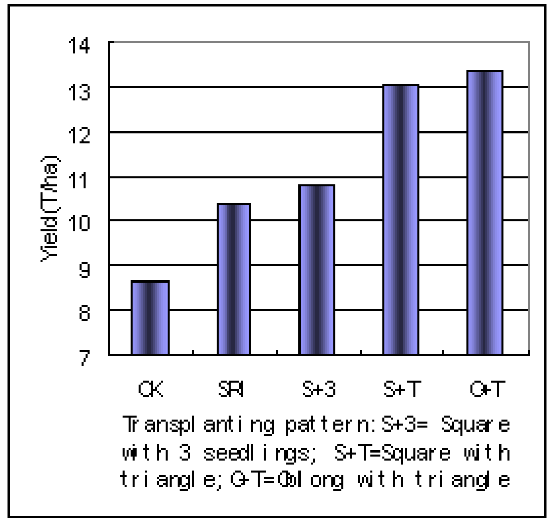


Fig.1 Relation between yield and transplanting density

Fig.2 Yield differences between transplanting pattern

2.4 Application of herbicide before transplanting, and mulching the spaces between plants with straw after recovery stage. Because of the wide spaces and more fertilizer, there are more weeds with SRI than with conventional cultivation, especially in the zero-tillage field. Combining herbicides and mulching measures, the weeds can now be reduced.

2.5 Adding chemical fertilizers to promote plant growth. The effect of organic fertilizer is slower than chemical fertilizer. Hence chemical fertilizer is used in SRI to promote tillering during productive tillering stage.

2.6 Inhibiting tillering after productive tillering stage. The tillering ability of rice plants is very strong, and the panicle to tiller ratio is often less than 50% in SRI. Hence a mid-season drainage is recommended for SRI field to inhibit excessive tillering (data not shown).

2.7 Making shallow furrows before transplanting in the zero-till fields. This is required as the alternate wetting and drying (AWD) method is a good way for water management and shallow furrows would help maintain AWD. This irrigation method is easy, resulting in the surface soil aerated while some water still remaining in the furrows.

3.The practice of super-high yields with SRI in Sichuan

Leshan City is a typical place where the rice-wheat cropping system is practiced, with well-developed irrigation systems. However, in conjunction with SRI cultivation, early-maturing crops such as mushrooms and vegetables would be much better than wheat. Improved SRI has been applied for 2 years in Leshan city during 2002 and 2003. The grain yield surpassed 12 t/ha in both years, certifying the SRI method by the Provincial Department of Agriculture in 2002 and by national experts in 2003. This is the new record of super-high yield in Sichuan ecosystem, being 46% greater than the yields obtained previously.

Conclusions

SRI, with its origin in Madagascar, is a new technique for rice culture in most areas across the world but the technique used in Madagascar is not suitable for Sichuan province. A modified-SRI according to the Sichuan ecosystem can increase rice yield significantly. The modifications include changes in transplanting density, leaf age, planting pattern, and field management.

References

Stoop W, Uphoff N and Kassam A (2002). A review of agricultural research issues raised by the System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems* 71:249-274.

Uphoff N, Fernandes EC, Yuan LP, Peng J, Rafaralahy S and Rabenandrasana J (2002) (Eds.). Assessing the System of Rice Intensification: Proceedings of an International Conference, Sanya, China, April 1-4, 2002. Ithaca, NY: Cornell International Institute for Food, Agriculture and Development. Available on SRI home page: http://ciifad.cornell.edu/sri/

Wang S, Cao W, Jiang D, Dai T and Zhu Y (2002). Physiological characteristics and high-yield techniques for SRI rice. In Assessments of the System of Rice Intensification: Proceedings of an International Conference, Sanya, China, April 1-4, 2002, 116-124. Ithaca, NY: Cornell International Institute for Food, Agriculture and Development.