Assessment of Using SRI with the Super Hybrid Rice Variety Liangyoupei 9

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The two-line super hybrid rice variety Liangyoupei 9 was studied with the cultivation methods of the System of Rice Intensification (SRI) in 2001. Its grain yield reached to 12.15 t/ha, a yield increase of 21.3% compared with use of conventional methods. This paper discusses methods used for analysis and the benefits of using SRI methods hybrid variety Liangyoupei 9.

SRI methods offer advantages of seeds-saving, nursery-saving, less water requirement, lower-cost, high yields and greater resource efficiency. They can also obviously decrease the amounts of chemical fertilizer and herbicides applied, improving the eco-environment of the soil and being good for developing organic agriculture. SRI methods, which were first put forward and used in Madagascar, have gotten the result of doubled grain yield.

In recent years, researchers in Indonesia, Philippines, China and other countries have been testing these methods. Professor Yuan Longping, Chinese academician, has actively promoted and introduced the new methods and has organized experiments in different ecological regions throughout country. The results reported here are from one of these experiments along the Yangtze River. The study evaluated the yield potentials and main technical points of SRI methods.

Materials and Methods

This experiment was carried out in Anqing Research Institute of Agricultural Sciences (ARIAS), which is located at 30 32' N latitude and 117 03' E longitude, in a northern subtropical climatic zone along the Yangtze River. The soil is an alluvium type with organic matter of 35.4g/kg. The total amount of N is 0.11%, P_2O_5 is 11.5mg/kg, and K_2O is 73 mg/kg. Thus the content of available effective P and K in this soil is low.

Genetic material

The two-line super hybrid rice variety Liangyoupei 9 was used as the experimental material for all the trials.

Experimental design

Two SRI plant densities were evaluated along with traditional cultivation (TRC) techniques:

- Treatment I: SRI spacing 33.3 x 33.3 cm (6,000 plants/667 m)
- Treatment II: SRI spacing 40 x 40 cm (4,168 plants/667 m)
- TRC conventional spacing: 16.7 x 26.7 cm (15,000 plants/667m).

The experimental area was 0.3 ha, with 0.1 ha for each treatment.

Field preparation

Thirty tons of compost (including 8 t chicken excrement) and 750 kg of rapeseed cake fertilizer were applied to the fallow paddy field before plowing. Field preparation was done according to normal cultivation methods. Each ridge (raised bed) was 350 m in length and 4m in width, with the width and depth of ridge furrow 20 cm and 25 cm, respectively.

The test materials were seeded in plastic trays on May 3, 2001. There were 19 x 30 holes in each tray which was 60 cm in length and 43 cm in width. Rice seedlings with 2.6 leaves at the age of 8-12 days were transplanted singly for the SRI trials. After the seedlings had recovered, the field was manually weeded four times.

The compost and rapeseed cake fertilizer used as base fertilizer contained, on a per hectare basis, 742.5 kg N, 46.5 kg P_2O_5 and 30 kg K_2O, and 150 kg of KH_2PO_4 per hectare was applied as dressing at the first weeding. The methods of disease and insect control used were the same as neighboring rice fields. Shallow irrigation was done in the panicle formation stage, with dry and wet conditions alternated for growth during the late stage.

Trait measurements and methods

Three representative locations, each with 20 rice plants, were selected to evaluate each treatment. Leaf age and dynamic formation of tillers were observed for the selected plants, and agronomic traits—spikelets, filled grains, seed-setting rate, and 1000-grain weight—were evaluated. Paddy grains were harvested and weighed for each treatment.

Results and Analysis

Yield increase

A yield of 12.15 t/ha was obtained in treatment I, which was 21.3% higher than TRC (10.02 t/ha), and 11.25 t/ha in treatment II, 12.3% more than TRC. The results showed that the SRI methods had a significant effect on increasing yield (Table I). The theoretical yield for the two treatments reached 15.85-17.56 t/ha, indicating that there still was more yield potential under SRI methods.

Contributions to yield increase

Increase of effective panicles formed the basis for higher yield. In the experiment with SRI methods using Liangyoupei 9, even though only 60,000-90,000 plants per hectare were transplanted, 60-70 tillers and 45-50 effective panicles were formed from each plant (Table 1). Effective panicles with treatments I and II reached to 4.050 and 3.075 million per hectare, respectively, an increase of 26.6-66.7% compared with TRC having 2.430 million effective panicles per hectare. Therefore, the increase of effective panicles established the solid foundation for higher yield.

Larger panicles with more grains were the key to higher yield. In Table 2, we see that SRI methods produced more low-order tillers and therefore formed more effective panicles. The tiller from the main stem (TMS) and tillers from the primary tillers (TPT) in treatment I accounted for 71.1% of total tillers, and the total number of grains and filled grains per panicle were respectively over 220 grains and about 200 grains. TMS and TPT tillers in treatment II accounted for 72.8% of total tillers, and spikelets and filled grains per panicle were similar to treatment I, although the number of spikelets and filled grains per panicle from TPT tillers increased greatly compared with treatment I, which were, respectively, 196.2 grains, 176.2 grains, and 176.1 grains. There were a lot of tillers produced in treatments under SRI methods, and most of the tillers grew earlier and were located at low nodes. Moreover, there were enough sunlight, air and water with SRI methods so that large panicles with more grains were formed compared with TRC and the rate of seed setting was higher than with TRC. Thus, it can be seen that large panicles and more panicles developed coordinately.

The high rate of seed-setting and 1000-grain weight also contributed to high-yield. The rates of seed-setting in two treatments were, respectively, 85.0% and 01.1%, which were 0.5%-5.6% higher than with TRC (84.5%); 1000-grain weights were, respectively, 25.5 g and 26.1 g, i.e., 0.3g-0.9 g more compared with that of TRC. The rate of seed-setting and 1000-grain weight in the two treatments did not increase markedly, but they contributed to higher yield in combination with more effective panicles.

Table 1. Comparison of agronomic and yield of Liangyoupei 9 with SRI methods

Treatment	I (33.3 x 33.3 cm)	II (40 x 40 cm)	TRC (16.7 x 26.7 cm)
Maximum number of tillers/hill	62.1	68.2	13.0
Effective panicles/hill	45.2	49.3	10.8
Rate of effective panicles (%)	72.8	72.3	83.1
Total grains/panicle	200.2	221.6	218.1
Filled grains/panicle	170.1	197.4	184.0
Rate of seed setting (%)	85.0	90.1	84.5
1000-grain weight (g)	25.5	26.1	25.2
Actual yield (t/ha)	12.15	11.25	10.02
Theoretical yield (t/ha)	17.56	15.85	11.31
Yield increase over TRC (%)	21.3	12.3	—

Table 2. Regulation of tillering, formation of effective panicles, and yield structure

SRI treat-ment	Order of tillering	Number of tillers	Number of effective panicles	Rate of effective panicles (%)	Contribution of each order to total number of tillers (%)	Grains per panicle	Filled grains per panicle	Rate of seed setting (%)
I	TMS	11.0	10.0	90.9	22.2	222.7	201.4	90.0
	TPT	29.0	22.0	76.0	48.9	222.8	194.1	84.8
	TST	20.0	13.0	65.0	28.9	157.3	132.0	83.1
	TTT	2	0	0	0	0	0	0
	Total	62.0	45.0	72.6	–	–	–	–
II	TMS	10.0	9.0	90.0	20.0	225.1	205.61	91.4
	TPT	32.0	26.0	81.2	52.8	223.4	202.3	90.5
	TST	24.0	14.2	63.3	27.2	196.2	176.1	89.8
	TTT	2	0	0	0	0	0	0
	Total	68.0	49.2	72.4	–	–	–	–

**TMS = tillers from main stem; TPT = tillers from primary tiller; TST = tillers from secondary tiller; TTT = tillers from third tiller.*

Growth Characteristics of Liangyoupei 9 with SRI Methods

Early tillering and vigorous tiller potential

We found that there is dynamic curvilinearity of tillering development of Liangyoupei 9 under treatments I, II and TRC. But, the curvilinearities of treatments I and II both ascended more steeply. This indicates that Liangyoupei 9 with SRI method had a more vigorous tillering potential and good regulation of leaf and tiller growth.

The periods of vegetative growth of the first two treatments in the field were 20 days longer with treatments I and II than with TRC. Yet the time of maximum tillering in these treatments was the same as with TRC. So under SRI methods, there were much longer period of effective tiller formation and thus more tillers in treatments I and II so that more effective panicles formed from early low-order tillers.

High resistance to diseases and lodging

According to our investigation in the field, the incidence of rice sheath blight in treatments I and II ranged from 58.4% to 54.6%, lower than that with TRC (70%). Also the indexes of disease grade were lower than for TRC, as was incidence of rice false smut. With SRI methods, there were still one or two green functional leaves in the treatments at maturing stage because of the strong root system, while the functional leaf of TRC trials became yellowish, and some rice plants lodged.

Key Techniques of SRI Methods for Super Hybrid Rice Variety

Application of more organic fertilizer and quality compost

Super hybrid rice varieties need more fertilizer, especially the proportion of balanced application of N, P and K. Therefore, a large amount of organic fertilizer application and balanced application of N, P and K are important for high yield. The amount of organic fertilizer should not be less than 30 t/ha. Other organic fertilizer such as rapeseed cake fertilizer and green fertilizer instead of compost are considered effective.

Ridge cultivation

Field preparation was done according to the normal cultivation methods used with hybrid varieties. Each ridge (raised bed) was 250 m in length and 4 m in width, and the width and depth of the ridge furrows was 20 cm and 25 cm, respectively. All these preparations were to control better the wetness of the field during irrigation. They assured that there was no water laying on the field during the vegetative growth phase of the crop.

Dry nursery in plastic trays

The number of seedlings when transplanting super hybrid rice with SRI methods was fewer than with conventional cultivation. It was simple and convenient to use plastic trays for raising seedlings, and dry cultivation of the nursery was also beneficial to boost the vigorous root system for early and quickly growing of tillers after transplanted. The plastic tray with big holes was good for root development. With SRI, the seedlings should be transplanted in a timely way. Seedlings with 2.6 leaves at an age of 8-12 days are suitable for being transplanted.

Field management

Weeds grew very rapidly due to having fewer rice plants in the field and no water layer according to SRI methods. Weeds should be removed not only earlier but also more times, which makes the plow layer looser and for more air permeability in the soil. After transplanting, the prevention from rice thrips damage is very important. In the first phase of rice growth, water was kept in the furrows at all times to maintain moisture in the field. Shallow water was applied through irrigation in the panicle-formulation stage. Irrigation was applied alternatively for wetting and drying of the field. Water supply did not stop earlier in later stage.

Prospects of Economic Benefit

Saving of seed and nursery costs

The amount of hybrid seed of Liangyoupei 9 needed was only 3.0-4.5 kg/ha with the SRI methods, giving in general a seed saving of 8.3-10.5 kg and a nursery saving of 90% which could save a cost of about 215 Yuan/ha.

Saving of fertilizer cost

Mainly compost and stall fertilizer were applied to Liangyoupei 9 with SRI methods, while with conventional methods, 10.0-12.0 t/ha of fertilizer would be applied, about 450-600 kg of urea and 275-450 kg of compound chemical fertilizer, with a cost of chemical fertilizer amounting to about 1,200 Yuan/ha. Although SRI methods might increase the cost of labor for making compost and weeding in the field, they reduced the use of chemical fertilizer and herbicides and are also beneficial to the eco-environment system, lowering costs and decreasing paddy pollution.

Saving water resources

SRI methods are well-adapted to water-saving irrigation with no water layer maintained on the field. The amount of field evaporation was only 1/4-1/6 of that with conventional irrigation methods. So SRI saved about 3,000 tons of water, equal to about 150 Yuan/ha.

The total saving with SRI methods thus amounted to about 1,555 Yuan/ha. In addition, the rice grain yield was raised by 15%, which amounted to an increase of 1.5 tons of rice per hectare, which is worth about 1,500 Yuan. So the total additional profit with these methods was more than 3,000 Yuan/ha.

SRI methods with Liangyoupei 9 can fully develop the hybrid variety's tillering potential, with larger panicles having more grains, higher resistance to pests and diseases, and good rice quality. It had an obvious effect for increasing production and has a large potential in increasing yield. If the SRI cultural practices level can be further enhanced, an expected yield of 15 t/ha can be acquired in single-cropping rice along the Yangtze River valley.

SRI methods not only have the advantages of seed-saving, nursery-saving, high yield and efficiency, but also decrease the application of chemical fertilizers and herbicides through the increased use of organic nutrients. SRI practices energetically improve soil structure and the eco-environment. Also, they are beneficial to the development of organic agriculture.

Under the conditions of diminishing water resources available within the single-cropping rice region north of the Yangtze River, SRI can be beneficial to the development of water-saving agriculture. Thus, it can be concluded that SRI represents an important innovation in rice cultivation technique and will have a wide developing prospect.