Physiological Characteristics and High-Yield Techniques with SRI Rice

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Physiological characteristics and high-yield cultivation techniques under SRI (system of rice intensification) condition were studied with the cultivars of Wuyuegeng 9, 9916 and Liangyoupeijiu. The results showed that the SRI significantly enhanced the following: root viability; contents of soluble sugar; non-protein nitrogen; proline and malondialdehyde (MDA) in leaf; dry matter in vegetative organs; partitioning percentage of stored carbohydrate and nitrogen; percentage of effective leaf area; spikelet number per unit leaf area; single stem and sheath weight; and percentage of productive tillers.

Under SRI cultivation, rice population growth and harvest yield differed with variety. On Indica rice, population tiller number at effective tillering stage, spike number and yield under SRI were 5% lower than those under conventional cultivation. However, on Japonica rice, no difference in population spike number between SRI and conventional cultivation was observed, while under SRI cultivation, population quality and biomass partitioning efficiency increased distinctively, and grain yield was 11750 kg/ha, higher than that under conventional cultivation (11497 kg/ha).

With Indica rice, if one seedling per hill was changed to two seedlings per hill, population tiller number at effective tillering stage and spike number increased obviously, yield difference between two cultivation systems decreased, and with suitable nitrogen fertilization, grain yield under two seedlings per hill of SRI was higher than that under conventional cultivation. In Wuyuegeng 9, with 150 kg/ha nitrogen fertilization, the yield with two seedlings per hill of SRI cultivation (9253 kg/ha) was 200 kg/ha higher than under conventional cultivation. However, dry matter production and translocation from vegetative organs after heading decreased and population size and spike number were enhanced with increasing nitrogen fertilizer. Therefore, yield increase under SRI cultivation should not rely on the excess nitrogen fertilization.

Rice has been well adapted to inundation and half-hydrophytic environment. However, part of water requirement in rice is only to meet the ecological demand of improving nutrient uptake, soil processes, and thus is of certain plasticity. Studies inside and outside China have provided some effective water-saving irrigation methods such as thin and shallow moist irrigation, intermittent irrigation, SRI cultivation and so on.

The common characteristic of above-mentioned irrigation methods is that no water layer is maintained on paddy field or soil water content is lower than saturated water content in a period of time during rice growth. Especially, the SRI cultivation technique has been extended and applied in Southeast Asia, and produced significant social, economic and ecological benefits.

To elucidate the basis of high yield with SRI, the present study was conducted to determine the differences in plant physiology, population development, yield formation between SRI and conventional rice cultivations as well as impact of management techniques on the SRI performance.

Materials and methods

Experiment design

Four experiments were conducted from 1999 to 2001.

Experiment 1

The experiment consisted of two cultivation methods: SRI and traditional rice cultivation (TRC). Under SRI treatment, 12 to 13-day-old rice seedlings with two leaves were transplanted, one seedling per hill. From transplanting to 7 days after transplanting, a water layer of 1 to 3 cm deep was maintained on the paddy field. From 7 days after transplanting to maturity, there was no water layer on the field, and soil water was main-

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tained in moist condition by quick irrigation as desired. In addition, the lowest water contents of the paddy field were maintained at 85% field capacity from 7 days after transplanting to effective tillering stage, 70% field capacity from effective tillering stage to emergence of the second leaf from the top, 85% field capacity from emergence of the second leaf from the top to ten days after heading, and 75% field capacity from 10days after heading to maturity. When soil water was lower than the lowest water content, no water layer was added in the afternoon.

Under TRC treatment, 28 to 30-day-old rice seedlings with five leaves were transplanted, with two seedlings per hill. A water layer of 1-5 cm deep was maintained on the rice field during the entire growth period except at the ineffective tillering stage, which was under moderate drought.

Experiment 1 was conducted in concrete boxes and designed as a randomized block with three replications. The concrete box was 1 m long, 1 m wide and 0.8 m high, with bottom coverage and rainproof at 2.5 m high. Uniformly mixed soil was loaded 30 days before transplanting, with total soil nitrogen and fast available nitrogen at 0.09% and 54.7 mg/kg, respectively; field capacity of top 10 cm soil layer was 25.89 g water per 100 g dry soil.

The experimental variety was Wuyuegeng 9 (local Indica cultivar), transplanting spacing was 25×15 cm; nitrogen rate was 300kg/ ha, and manual irrigation was provided and measured with tap water.

Experiment 2

This experiment was carried out in Jiangyin city, Jiangsu Province. Contents of soil total nitrogen, fast available nitrogen were 0.15% and 108.7 mg/kg respectively. The experiment consisted of three planting densities as 30×20 cm (D1), 25×25 cm (D2), 30×30 cm (D3) under SRI cultivation; plus the control with 30×12 cm planting density under conventional cultivation (TRC2). Detailed management practices were the same as in experiment 1, except that variety 9516 (a common Indica cultivar) was used. The experiment was designed in randomized block with three replications.

Experiment 3

This experiment was conducted in Jiangsu Academy of Agricultural Sciences. Contents of soil total nitrogen and fast available nitrogen were 0.12% and 85.1 mg/kg, respectively. The experiment consisted of six treatments as non nitrogen fertilization × one seedling per hill (S1), non nitrogen fertilization × two seedlings per hill (S2), 150 kg/ha nitrogen × one seedling per hill (S3), 150 kg/ha nitrogen × two seedlings per hill (S4), 300 kg/ha nitrogen × one seedling per hill (S5), 300 kg/ha nitrogen × two seedlings per hill (S6). The treatments were imposed under SRI cultivation, with 25×25 cm planting density; the same irrigation criteria and transplanted seedling age as in experiment 1. The control was 30×12 cm planting density under conventional cultivation (TRC2) with variety Wuxianggeng 9; other cultivation practices were the same as in experiment 1. The experiment was designed in randomized block with three replications.

Experiment 4

This experiment was carried out on Jiangpu farm of Nanjing Agricultural University. Contents of soil total nitrogen, fast available nitrogen were 0.14% and 99.6 mg/kg, respectively. Demonstration of SRI cultivation with normal Indica and hybrid rice was conducted in 3000 m^2 field, which was equally divided into four blocks.

The experiment consisted of four treatments: normal Indica rice × SRI (CSRI) with 25×25 cm planting density, one seedling per hill; normal Indica rice × conventional cultivation (CTRC), 25×15 cm planting density, two seedlings per hill; hybrid rice × SRI (HSRI), h 30×30 cm planting density, one seedling per hill; and hybrid rice × conventional cultivation (HTRC), 30×15 cm planting density, two seedlings per hill. Varieties used were Wuyuegeng 9 (Indica rice) and Liangyoupeijiu (hybrid rice). The other cultivation practices were the same as in experiment 1.

The seedlings in all experiments were raised in a dry-land nursery. Basal application of phosphorus and potassium fertilizers was done at rates of 135 kg P_2O_5/ ha and 210 kg K_2O/ha. Nitrogen was applied as follows: 50% as basal fertilizer, 10% as tillering fertilizer; 20% as early flowering fertilizer, and 20% as late flowering fertilizer.

Measurements and Observations

A plastic ruler was inserted into a fixed position of each plot to measure water layer height. When no water layer in field was observed, soil water content down to 10 cm was measured with dry weight method after an interval of three days. Plant dry matter was measured at the stages of transplanting, effective tillering (N-n), jointing (n-2), heading, and maturity. 100 seedlings were sampled at transplanting stage; and at other stages, two to five hills of plants were sampled according to average tiller number in each plot to measure dry weights of leaves, stems, sheathes and spikes.

Total nitrogen, protein nitrogen and non-protein nitrogen were measured with Kjeldahl's method, soluble sugar and starch contents by Anthrone Colorimetric method, malondi-aldehyde (MDA) content with TBA method, Proline content with Acidic Ninhydrin method, and root oxygenation ability of ∝-NA was measured by consulting Zhangxianzheng method.

Results and Analysis

Physiological differences between SRI and conventional rices

Root activity

Figure 1 showed that during each development stage, root activity in SRI rice was significantly higher than in conventional rice (TRC). Root oxygenation ability of ∝-NA under SRI treatment was 1.9 times more than under TRC treatment at N-n stage, 2.3 times more at n-2 stage, 2 times more at heading stage and 2.9 times more at maturity. The enhanced root activity during the entire growth period, especially during late growth stage, was an important physiological characteristic in SRI rice plants.

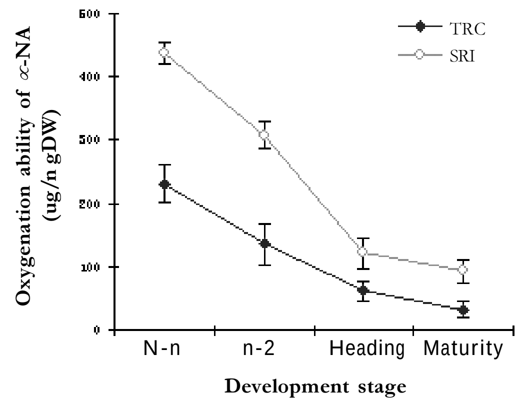
Carbohydrate and nitrogen content and physiological activity in leaf

Contents of soluble sugar, non-protein nitrogen, MDA and proline in leaves of SRI rice were obviously higher than those in conventional rice. Soluble sugar, non-protein nitrogen, MDA and proline contents in leaves of SRI rice were 54.5%, 24.6%, 32.7% and 11.7% higher at jointing stage, and were 61.5%, 23.4%, 103.8% and 26.5% higher at heading stage than those of conventional rice, respectively (Table 1). As main osmotic regulators in rice plant, accumulation of soluble sugars and non-protein nitrogen would enhance rice ability for drought tolerance, which was another important physiological characteristic of SRI rice. The higher content of MDA under SRI treatment implied that drought damage in SRI rice could be more serious than in TRC rice.

Assimilate translocation after heading

Accumulation of carbohydrates, nitrogen and dry matter in vegetative organs of rice reached the maximum at full heading stage; then the stored assimilates partitioned to spikes gradually. Table 2 shows that with SRI treatment, the absolute partitioning rate of stored matter from vegetative organs was remarkably higher than with TRC treatment. The rates of dry matter and stored carbohydrate from leaves were more than three times, and from stems and sheathes were about 1.4 to 1.7 times of those with TRC treatment. The total translocation of nitrogen from leaves, stems and sheathes was 66.9% higher, and apparent translocation percentage from leaves, stems and sheathes were distinctively higher than with TRC treatment. Higher translocation and conversion rates of stored matter from vegetative organs was of significant importance for enhanced grain filling and spike weight in SRI rice.

Figure 1. Root activity in SRI and conventional rices (Wuxianggeng 9)



Differences in population development between SRI and conventional rices

Population tiller number and dry matter accumulation

Under typical SRI cultivation of one seedling per hill and slight drought stress in the paddy field, population tiller numbers including final spike number at all growth stages were obviously lower than those in conventional rice. Figure 2 shows that with SRI treatment, spike number was 5.4% lower than that with TRC treatment. Harvest yield with SRI treatment was 7846.2 kg/ ha at maturity, 5.5% lower than that with TRC treatment (significant difference). The reduction in spike number was proportional to yield reduction, indicating that a lack in spike number largely limited the harvest yield of SRI rice.

At the jointing stage, dry matter accumulations under SRI and TRC treatments were 3916 kg/ha and 4096 kg/ha, respectively. At heading and maturity stages, dry matter accumulation under SRI treatment were 10,479 and 19,139 kg/ha, slightly higher than 10,136 and 18,910 kg/ha under TRC treatment with the differences insignificant.

Table 1. Contents of soluble sugar, non-protein nitrogen, malondialdehyde (MDA), and prolinein leaves of SRI and conventional rices (Wuxianggeng 9)

Treatment	Development stage	Content of soluble sugar (umol/gFW)	Content of non-protein nitrogen (g/kg DW)	Content of malondialdehyde (nmol/gFW)	Content of proline (ug/gFW)
TRC	Jointing	30.32±2.17	5.7±0.4	7.37±0.31	13.54±0.65
	Heading	198.51±17.81	7.7±0.7	10.25±0.66	14.53±1.54
SRI	Jointing	46.84±3.11	7.1±0.7	9.78±1.01	15.13±0.20
	Heading	320.63±20.38	9.5±0.1	20.89±1.42	18.38±1.61

Table 2. Translocation of assimilate in SRI and conventional rices (Wuxianggeng 9)

			Translocation of assimilate from organs (kg/ha)			Apparent translocation percentage (%)			Apparent conversion percentage (%)		
Treat-ment	Item	Net accumulation in spike (kg/ha)	Leaf	Stem & sheath	Leaf, stem& sheath	Leaf	Stem & sheath	Leaf, stem & sheath	Leaf	Stem & sheath	Leaf, stem & sheath
TRC	Dry matter	9403.2	110.1	518.9	629.1	3.5	10.6	7.8	1.2	5.5	6.7
	Carbohydrate	7376.6	76.9	343.1	419.9	26.0	47.6	41.3	1.0	4.7	5.7
	Nitrogen	90.9	12.4	18.1	30.5	18.4	30.7	24.1	13.6	19.9	33.5
SRI	Dry matter	9889.3	341.1	887.7	1228.8	9.9	18.3	14.8	3.5	9.0	12.5
	Carbohydrate	8414.9	242.4	488.2	730.6	55.7	60.7	59.0	2.9	5.8	8.7
	Nitrogen	95.3	21.8	29.2	50.9	31.5	45.5	38.3	22.9	30.6	53.5

*Note: Apparent translocation percentage (%) = [dry matter or carbohydrate or nitrogen at full heading stage - dry matter or carbohydrate or nitrogen at maturity] / dry matter or carbohydrate or nitrogen at full heading stage * 100*

*Apparent conversion percentage (%) = [dry matter or carbohydrate or nitrogen of organs at full heading stage - dry matter or carbohydrate or nitrogen of organs at maturity] / net accumulation of dry matter or carbohydrate or nitrogen in spikes * 100*

Differences between SRI and TRC treatments were highly significant (P<0.01)

Table 3. Population quality indices of SRI and conventional rices (Wuxianggeng 9)

	Heading stage						
Treatment	LAI	Effective LAI	Effective leaf area percentage (%)	Total spikelet number (million/ha)	Spikelet number per unit leaf area (number/cm2)	Dry weight of stems and sheathes (g/Tiller)	Percentage of productive tillers (%)
TRC	7.85	7.14	90.93	365.44	0.465	1.79	67.29
SRI	7.13**	6.99	97.97**	370.09	0.519**	1.87	77.17**

*** Difference between SRI and TRC treatments highly significant (P<0.01).*

Population quality

SRI cultivation had an improving effect on population quality (Table 3). Percentage of productive tillers under SRI treatment was distinctively higher than that under TRC treatment. Total population spikelet number, single stem and sheath weight, and spikelet number per unit leaf area at heading stage of SRI exhibited an increasing trend, and thus sink demand for source assimilate was enhanced, which might be the fundamental reason for higher assimilate translocation percentage in SRI rice.

Figure 2. Tiller dynamic of SRI and conventional cultivation rice (Wuxianggeng 9)

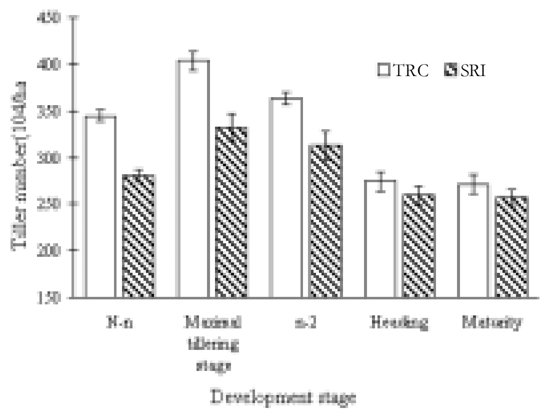
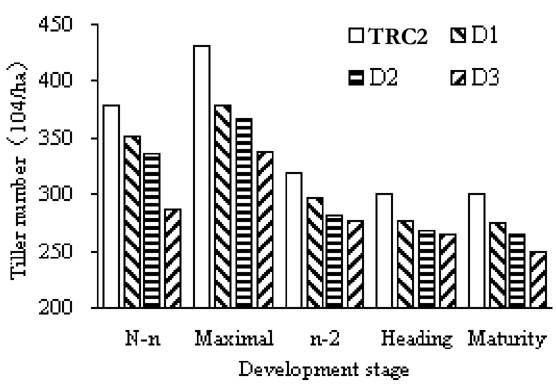


Figure 3. Population tiller number in SRI rice with different planting standards



Impact of cultivation factors on growth and yield of SRI rice

Regulation of transplanting standard on tiller number and yield

With the increase in planting density from 30×30 cm to 30×20 cm — 111.100 to 166.700 ten thousand/ha — the population tiller number of SRI rice during main growth stages was enhanced to a certain degree, with the largest increase at N-n stage. Planting density under D1 treatment was higher than that under D2 and D3 treatments, yet tiller number at N-n stage under D1 treatment was slightly lower than that under conventional cultivation (Figure 3). The number of matured spikes with the three planting densities under SRI cultivation was 8.2%, 11.5% and 16.8% lower than under conventional cultivation, and yields decreased 4.1%, 7.8% and 5.9% respectively (Table 4). These data indicate that increasing planting density could only partly compensate for the limited capacity in tiller production with the SRI.

Impact of combining density and N on population quality, photosynthetic ability, and yield

Increasing seedling number per hill and nitrogen fertilization can promote the population development in SRI (Figure 4). Population tiller number at effective tillering stage with two seedlings per hill was remarkably enhanced as compared to one seedling per hill. The effect of nitrogen fertilization on tiller number was greater with treatment of two seedlings per hill than with one seedling per hill. When the rate of nitrogen fertilization was over 150 kg/ha N, the population tiller number at effective tillering stage under the two

Table 4. Yield and yield components of SRI rice with different planting standards

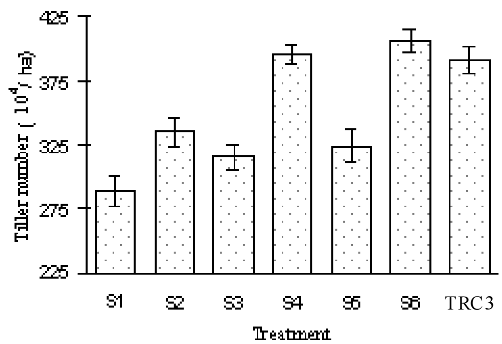
Planting standard	Spike number (10^4/ha)	Grain number per spike	Percent ripened grains (%)	Thousand grain weight (g)	Yield (kg/ha)
D1 (30 x 30 cm)	274.80	128.45	94.10	26.53	8535.0
D2 (25 x 25 cm)	265.05	126.45	93.55	26.72	8205.0
D3 (30 x 30 cm)	249.15	152.23	87.01	26.96	8370.0
TRC2 (30 x 12 cm)	299.55	130.35	89.51	26.17	8896.5

seedlings per hill (S4 and S6 treatments) was higher than under conventional cultivation. These results indicated that a combination of two seedlings per hill and suitable nitrogen rate could promote population tiller number in SRI rice up to that in conventional rice.

Dry matter accumulation at heading stage enhanced with the increasing nitrogen rate, and the effect was 1000 kg/ha greater under two seedlings per hill than under one seedling per hill, and was over 2000 kg/ha higher at 300 kg/ha N than at 150 kg/ha N (Table 5). Enhancement of seedling number per hill appeared to increase dry matter production after heading, although the difference was insignificant, whereas excess nitrogen tended to decrease dry matter production after heading. For example, dry matter production after heading under S6 treatment was 6.7% lower than that under S4 treatment.

Table 6 shows that effective and high effective leaf area percentages were higher with two seedlings per hill than with one seedling per hill, but lowered at highest N rate. With increased N, the chlorophyll content (SPAD), the maximum fluorescence efficiency (Fv/Fm) and photosynthetic rate of the last four leaves at heading stage was enhanced, but the extinction coefficient increased remarkably, and thus light penetration ability into the canopy decreased. The results indicated that the treatment of two seedlings per hill could increase effective and high effective leaf area percentages, but decrease photosynthesis ability of single leaf, whereas enhanced nitrogen rate could increase population LAI and photosynthesis ability of single leaf, but decreased effective and high effective leaf area percentage and light penetration ability.

Figure 4. Population tiller number at N-n stage with the treatments combining density and fertilizer (Wuxianggeng 9)



Yield and yield components remarkably differed under the treatments combining different densities and N rates. Harvested spike number with two seedlings per hill was higher than that with one seedling per hill, and was reduced with decreasing N rates. Grain number per spike was enhanced significantly with the increasing nitrogen rate. The percentage of ripened grains and thousand-grain weight with one seedling per hill tended to be higher than with two seedlings per hill. Percentage of ripened grains at different nitrogen levels was in the following order: low nitrogen > no nitrogen > high nitrogen. Thousand-grain weight appeared to

Table 5. Main population quality indices with the treatments combining density and fertilization (Wuxianggeng 9)

Treatment	Heading stage: LAI	Heading stage: Spikelet number (million/ha)	Heading stage: Spikelet number per unit leaf area (number/cm2)	Heading stage: Weight of stem and sheathe (g/Tiller)	Heading stage: Dry matter accumulation (kg/ha)	Dry matter accumulation after heading (kg/ha)	Percentage productive tillers (%)
S1	4.53 fD	253.7 eD	0.56 eD	1.63 dE	6863.7 fF	6662.9 a	73.65 eD
S2	5.14 eD	359.8 dC	0.70 bAB	1.91 bB	8136.5 eE	7697.1 a	84.66 bB
S3	5.83 dC	408.1 cdC	0.70 bAB	1.80 bcBCD	9500.6 dD	7144.5 a	79.29 cC
S4	6.96 cB	515.0 aA	0.74 aA	2.14 aA	10617.1 cC	7833.1 a	88.35 aA
S5	7.28 bcB	458.6 bB	0.63 cdC	1.74 cdCDE	11714.1 bB	6852.0 a	77.14 dC
S6	8.24 aA	535.6 aA	0.65 cBC	1.85 bcBC	12853.3 aA	7306.1 a	85.81 bAB
TRC3	7.52 bB	451.9 cBC	0.60 dCD	1.67 dDE	11746.7 bB	6442.7 a	84.87 bB

Table 6. Photosynthetic ability at heading under the treatments combining density and fertilization (Wuxianggeng 9)

Treatment	Effective leaf area (%)	High effective leaf area (%)	Average value of the last four leaves			Population extinction coefficient
			SPAD	Fv/Fm	Photosynthetic rate	
S1	88.62	79.90	40.42	0.698	13.5	0.160
S2	94.81	84.65	39.24	0.696	12.8	0.178
S3	93.19	81.65	43.62	0.705	16.3	0.183
S4	97.69	85.72	42.28	0.701	15.1	0.194
S5	90.35	79.02	46.52	0.766	17.9	0.208
S6	93.43	82.88	45.47	0.752	17.8	0.224
TRC3	84.78	75.48	46.59	0.712	19.6	0.249

Table 7. Yield and yield components with the treatments combining density and fertilization (Wuxianggeng 9)

Treat-ment	Spike number (10^4/ha)	Percent of grain number per spike	Percentage of ripened grains (%)	Thousand-grain weight (g)	Yield (kg/ha)	Harvest Index (HI)
S1	222.04 fD	108.43 cC	91.39 bcB	27.73 aA	6236.4 eD	0.461 bcAb
S2	300.76 deC	109.43 cC	81.76 eD	24.37 cB	6397.7 dC	0.404 dB
S3	289.51 eC	116.47 bB	95.76 aA	26.30 abAB	8432.0 cB	0.507 aA
S4	363.99 bA	120.84 aA	86.70 dC	24.53 bcB	9253.2 aA	0.502 abA
S5	313.38 dBC	120.09 aA	90.11 cB	26.18 abAB	8694.2 bB	0.492 abA
S6	385.22 aA	108.96 cC	82.07 eD	25.26 bcAB	8479.9 bcB	0.421 cdB
TRC3	334.11 cB	115.64 bB	91.60 bB	25.86 bcAb	9050.8 bB	0.498 abA

decrease with enhanced nitrogen. The S4 treatment produced the maximum yield with 9253.2 kg/ha, as compared to the yield of TRC3 at 9050.8 kg/ha (Table 7). Data also indicated that two seedlings per hill accelerated assimilate distribution into grains under SRI cultivation, but high nitrogen inhibited translocation of stored assimilate from vegetative organs to grains. Thus, the combination of moderate nitrogen and two seedlings per hill was in favor of yield increase with SRI rice.

Responses of normal Indica rice and hybrid rice to SRI cultivation

Experiments with normal Indica rice and hybrid rice showed that responses to SRI cultivation differed with genotypes. Since hybrid rice had strong tillering ability and vegetative growth advantage, tiller number at effective tillering stage and spike number were similar between SRI and conventional cultivation. In contrast, significant differences were observed with Indica rice (Figure.5). Under SRI cultivation, dry matter accumulation at effective tillering stage and from heading to maturity with Indica rice decreased, whereas with hybrid rice, dry matter accumulation decreased only during ineffective tillering stage, but did not decrease during effective tillering stage and from heading to maturity (Figure 6). Yield under CS treatment was distinctively lower than that under CC treatment, but yield under HS treatment was close to that under HC treatment (Table 8).

Table 8. Yield and yield components for normal Indica and hybrid rices

Treatment: Variety	Treatment: Method	Spike number (10^4/ha)	Grain number per spike (grain/spike)	Percentage of ripened grains (%)	Thousand grain weight (g)	Yield (kg/ha)
Conv.	SRI (CS)	326.7	124.8	93.8	26.2	9837.0
Conv.	Conv. (CC)	363.5	122.2	91.3	26.7	10581.0
Hybrid	SRI (HS)	312.2	196.0	91.6	21.2	11749.5
Hybrid	Conv. (HC)	314.1	194.8	92.3	20.6	11497.5

Discussion

Physiological demand of water by the rice plant is indispensable for normal metabolic activities, but ecological water demand has certain flexibility. With the root zone kept moist under SRI cultivation, supplemental gas and heat were continuously provided into the soil on the basis of meeting physiological water demand, thus making the soil environment more suitable for rice root growth. This could be a major reason for enhanced root activity in rice plant of SRI. The reduced ecological water supply under SRI created a slight drought stress, as seen with the increased contents of soluble sugar, proline and malondialdehyde (MDA) in leaves. This water stress had little impact on hybrid rice with strong root and vegetative growth advantage, but did obvious impact on Indica rice with weak root and tillering ability, resulting in yield decrease in Indica rice. Thus, with Indica rice, improved cultivation techniques are needed under the SRI, such as enlarging population by two seedlings per hill.

Translocation rate and percentage of assimilate from leaves, stems and sheathes, conversion percentage of stored assimilate before heading, and harvest index with SRI rice were all higher than with conventional rice. It seems that slight drought stress improved population quality, especially grain number per unit leaf area at heading stage increased remarkably; thus the sink became larger and the source became smaller, and single plants became stronger. On the other hand, the leaf age at transplanting was young with the SRI, thus tillers occurred earlier and at lower tillering nodes on the stem. Commonly, SRI rice was transplanted with just two leaves, three leaves less than with conventional rice, and tillering began at five leaves. Maximum tiller number usually occurs before effective tillering stage when rice if grown under conventional (flooded) conditions. Tiller number was smaller with

Figure 5. Difference of tiller number between normal Indica rice and hybrid rice

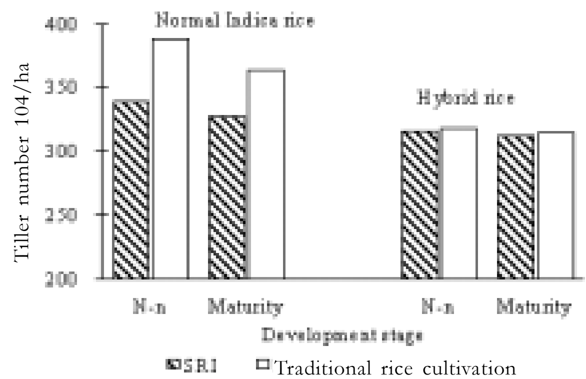
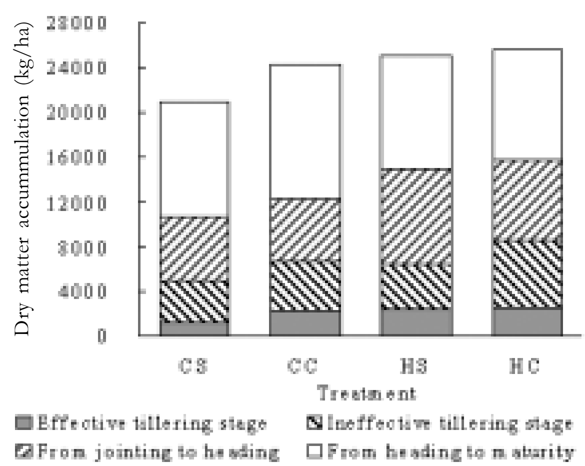


Figure 6. Difference of dry matter accumulation between normal Indica rice and hybrid rice



SRI, but tillers were larger and stronger, and single stem and sheath weight at heading was remarkably higher than with conventional rice.

In experiment 1, rice irrigation application was strictly measured. Without impact of rainfall and leakage, average irrigation provided during the whole rice growth period under SRI was 5,500 t/ha, about half of the 10,220 t/ha provided under conventional cultivation. Thus, water-saving efficiency under SRI was remarkable, with a 75% increase in irrigation water-to-grain ratio. However, irrigation applications during vigorous growth period were frequent, averaging one time every five to seven days; thus the labor cost of irrigation was fairly expensive. Further studies are needed to develop more effective irrigation techniques for SRI cultivation.