Physiological Effects of SRI Methods on the Rice Plant

Tao Longxing, Wang Xi, and Min Shaokai, China National Rice Research Institute, Hangzhou

The physiological effects of different rice crop management systems were studied by comparing the results associated with traditional methods of flooded rice irrigation (TRC) to non-flooded rice farming with young seedlings and wider spacing (SRI). SRI, we observe, forms high biomass by large individual plants, and dry matter accumulation after heading accounted for 40% of the total dry matter. More than 45% of the material from stem and sheath was contributed to grain yield in SRI. At the same time, SRI facilitates a heavier and deeper root system.

However, several disadvantages were also observed with SRI: (1) There were less amount of root exudates with lower zeatin content and a lower respiration rate. (2) The flag leaf photosynthesis rate from filling stage to ripening stage decreased with SRI, and stomatal resistance was increased compared to traditional flooded irrigation. Some possible ways for increasing photosynthesis rate by improved physiological activity of the plant during the grain-filling stage were also examined.

Material and methods

Two hybrid rice varieties, Liangyou-peijiu (a two-line hybrid rice) and Xieyou 9308 (a three-line hybrid rice), were selected as testing material. The age of seedlings for the SRI trials was 15 days, with single seedlings planted at a density of 60,000 hill/ha. Water supply was limited and controlled, and 7.5 t/ha of organic fertilizer were applied as a basic treatment, with P and K supplied during panicle initiation. The TRC method was the traditional flooded irrigation system, with seedling age of 30 days, single seedlings, and transplanting density of 180,000 hill/ha. The factors observed were:

- Plant dry weight apportioning
- Light intensity in the canopy
- Distribution of root dry matter
- Weight-bearing ability on the base inter-node
- Output efficiency of the photo-nutrients
- Photosynthesis rate and stomatal resistance
- Root exudates, and
- Root respiration rate and cytokinin content.

Main results

Plant type with SRI

Larger individual plants were formed with SRI, facilitating better light distribution, as portrayed in the following figures.

Figure 1. Plant type and light intensity of SRI at heading stage

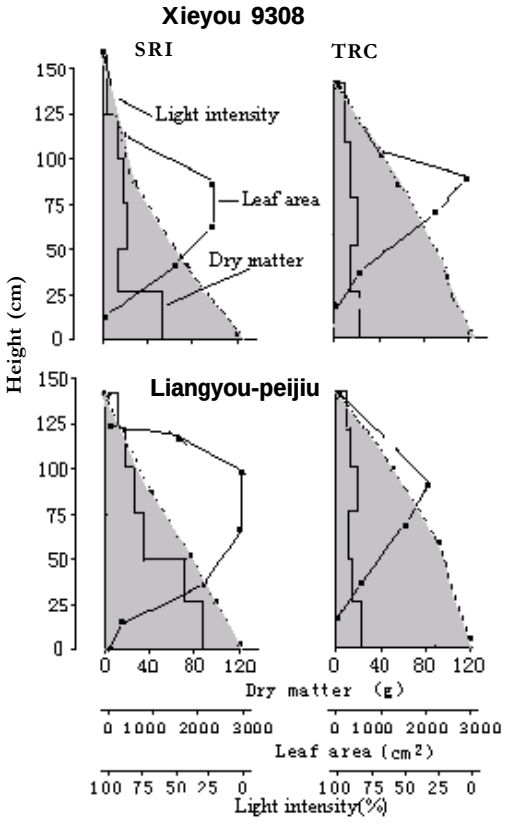


Figure 1 shows that (1) Plant height of Xieyou 9308 with SRI methods was higher than with TRC, although there was no significant difference in height for Liangyou-peijiu; (2) There was an evident difference in plant type between SRI and TRC for both hybrid varieties as the base inter-node weight-bearing ability (dry weight of the plant between 0~25 cm divided by the dry weight of the rest part of the plant) for Xieyou 9308 was 74.5% and 39.7% for SRI and TRC, respectively, and for Liangyou-peijiu, it was 63.4% and 33.3%; (3) The total leaf area with SRI was larger than with TRC for both hybrid varieties. Plant leaf area was mainly distributed at a height between 50 and 100 cm with SRI, and at 75 to 100 cm with TRC; (4) The plant type of SRI methods was improved with a better light distribution. With SRI, the light intensity of Xieyou 9308 at 75% of its height was 85% of the maximum, compared to 75% with TRC.

Root growth with SRI

Root growth was markedly greater in SRI plants. Figure 2 shows the root systems were distributed mainly from 0-20 cm depth in the soil. (1) Root dry weight per plant of Xieyou 9308 was 13.2 g and 8.2 g, respectively, with SRI and with TRC methods, and for Liangyou-peijiu, it was 9.8 g to 7.6 g; (2) Roots extended 10-15 cm deeper with SRI than with TRC.

Figure 2. Dry matter distribution of roots in SRI and TRC plants at heading stage

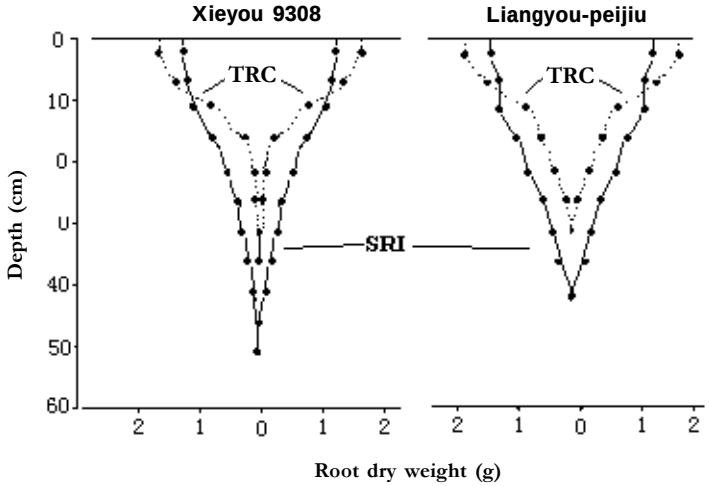


Table. 1 Dry matter production of rice plant on SRI (kg/ha)

Hybrid variety	Cultivation system	Initial tiller	During productive tillering	At panicle initiation	At heading	At yellow ripening
Xieyou 9308						
	SRI g/hill	1.31	25.8	49.1	168.3	276.0
	Kg/ha	78.6	1548	2946	10098	16560
	TRC g/hill	0.44	13.3	26.6	82.5	135.6
	Kg/ha	52.8	1596	3198	9903.5	16372
Liangyou-peijiu						
	SRI g/hill	0.86	28.6	56.4	207.4	340.0
	Kg/ha	51.6	1716	3384	12444	20400
	TRC g/hill	0.29	14.8	27.9	182.9	168.2
	Kg/ha	34.8	1776	3340	12352	20184

Dry matter production and distribution

From Table 1 we see that: (1) Dry matter accumulation for Liangyou-peijiu was higher than for Xieyou 9308 with both SRI and TRC methods; (2) Total plant dry weight with SRI was higher than with TRC, this difference becoming significant during the reproductive stage; (3) Biomass accumulation at full heading was about 40% of that for the total duration.

Figure 3 shows the photo-nutrient distribution during filling stage: (1) The output efficiency before the heading stage for Liangyou-peijiu was 47.3% and 38.0% for SRI and TRC, respectively, and for Xieyou 9308, it was 47.9% and 34.7%, respectively. The output efficiency was 10% greater with SRI than with TRC for both varieties; (2) The leaf sheath got yellow at the full heading stage for Xieyou 9308 with TRC, and at milk stage with SRI. The yellow leaf sheath appeared at the initial heading stage for Liangyou-peijiu, so Liangyou-peijiu appears more susceptible to senescence than Xieyou 9308; (3) The yellow leaf sheath in the base stem appeared later with SRI than with TRC.

Flag leaf photosynthesis rate and stomatal resistance

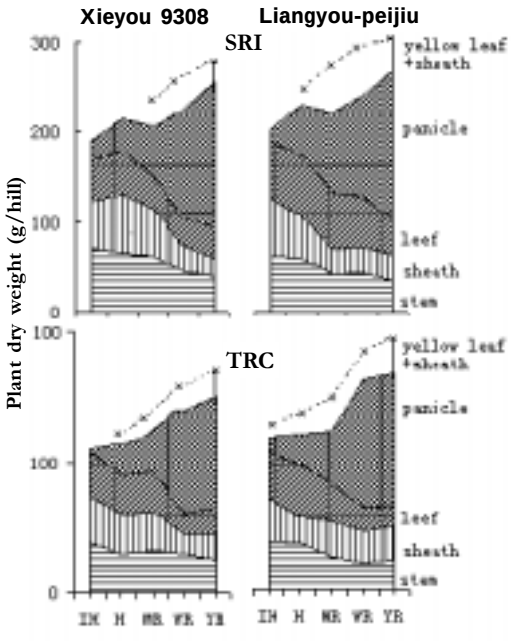
Figure 4 below shows that: (1) The flag leaf photosynthesis rate for both varieties was lower with SRI than with TRC; (2) Liangyou-peijiu suffered more than Xieyou 9308 as far as the photosynthesis rate was concerned; (3) The stomatal resistance rate increased after flowering for both varieties with SRI methods.

Root physiological activity of SRI

The amount of material exuded from the root when cut can be regarded as an index of root physiological activity and also as a signal of stem growth status. Note that this is not the same thing as "root exudates" which are the photosynthate that is exuded by the root system into the rhizosphere and utilized by soil biota.

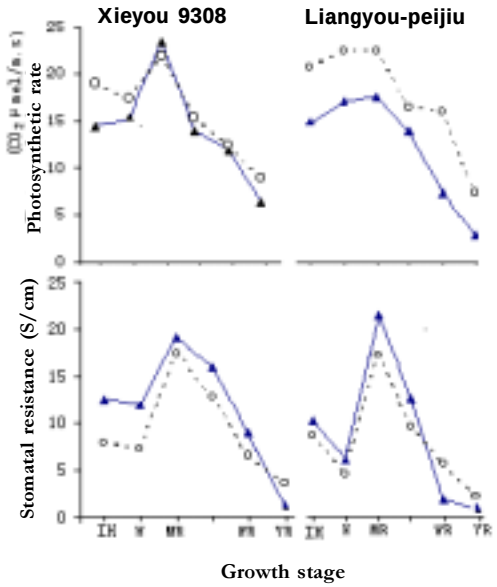
It can be seen from Figure 5 that: (1) The material exuded by the root was, somewhat surprisingly, less with SRI than with TRC in both of the hybrid varieties used in this experiment; (2) This exudation increased as the stem and root system increased, and reached a maximum value at panicle initial stage, then sharply decreasing after heading stage. There was no significant

Figure 3. Dry matter distribution of rice plants during ripening stage



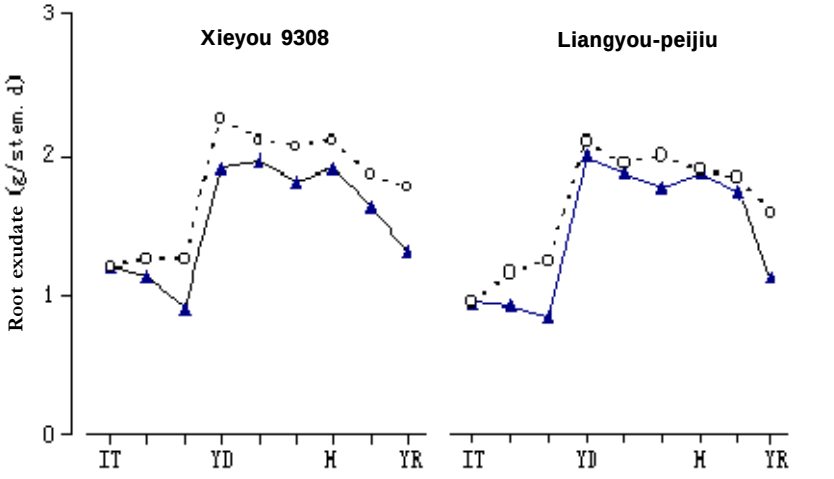
IH = Initial heading stage
H = Heading stage
MR = Milky ripening stage
WR = Wax ripening stage
YR = Yellow ripening stage
+—+ SRI o—o TRC

Figure 4. Photosynthetic and stomatal resistance rate of flag leaf during grain filling stage



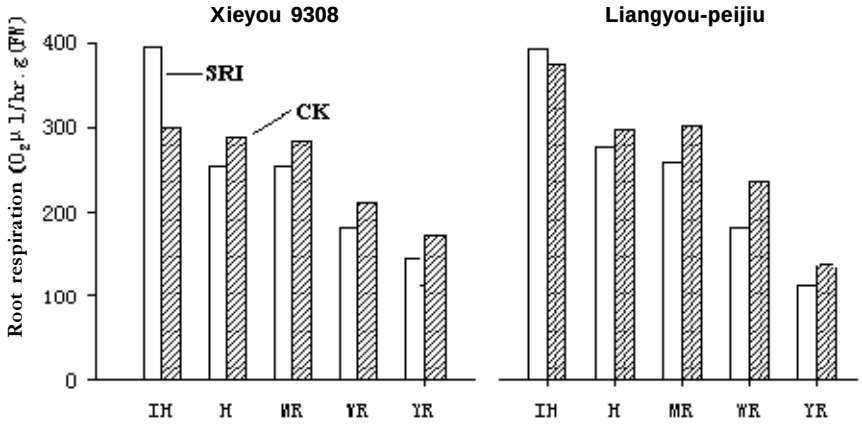
IH = Initial heading stage
H = Heading stage
MR = Milky ripening stage
WR = Wax ripening stage
YR = Yellow ripening stage
•—• SRI o—o TRC

Figure 5. Root exudates with SRI



IT = Initial tiller stage
YD = Young panicle development stage
H = Heading stage
YR = Yellow ripening stage
•—• SRI
o—o CK

Figure 6. Root respiration rate on SRI and TRC



IH = Initial heading stage
H = Heading stage
MR = Milky ripening stage
WR = Wax ripening stage
YR = Yellow ripening stage

difference between SRI and TRC in this regard as far as exudation dynamics were concerned; (3) The range of exudation decreased in SRI plants during the grain-filling stage was larger than in TRC plants.

Some plant hormones were measured in this experiment, as shown in Table 2. (1) The amount of cytokinins in root exudates was higher in Xieyou 9308 than in Liangyou-pei-jiu; (2) The amount of diHZR, a non-active zeatin form, was increased, while active zeatin plus iPA decreased as the rice stem got older; (3) The total amount of CTKs decreased in SRI compared with TRC. What a decrease in the zeatin value caused by SRI

Table 2. Cytokinin content in root exudation of hybrid varieties by planting method and growth stage (pM)

	Hybrid Variety											
	Xeiyou 9308						Liangyou-peiju					
	SRI			TRC			SRI			TRC		
	IH	H	YR	IH	H	YR	IH	H	YR	IH	H	YR
Zeatin	26.0	30.1	1.2	29.5	25.6	7.6	19.0	24.0	ND	24.1	31.0	4.6
iPA	0.9	1.6	1.5	1.2	2.4	1.5	0.7	1.9	1.2	1.2	4.3	2.1
diHZR	1.7	2.9	35.4	1.2	7.3	27.5	13.3	13.8	30.4	13.2	7.6	28.4
CTKs	28.6	34.6	38.1	31.9	35.3	36.5	33.0	39.7	31.6	38.5	42.9	34.5

IH = Initial heading stage
H = Heading stage
MR = Milky ripening stage
WR = Wax ripening stage
YR = Yellow ripening stage
CTKs = Cytokinins
Z = Zeatin
iPA N^6 = isopentenyla adenosines
diHV = Dihydrozeatin riboside

methods means for plant performance is not clear but is worth further investigation. Overall plant growth was greater with SRI, so one might have expected these hormone values to be higher. We are obviously just beginning to gain an understanding of the physiological processes that are affected or induced by the plant, soil, water and nutrient management activities combined in SRI. There remains much interesting research to be done.