Integrated System of Rice Intensification (ISRI) for Enhancing Crop and Water Productivity under Changing Climate

19 June 2014

A.K. Thakur, R.K. Mohanty & A. Kumar

Climate Change

Major threats for agriculture

More frequent and severe droughts, flooding, storm damage, cold snaps, untimely rains, and hot spells.

Today, the focus should be not just on producing more grain with less resources, but also on growing plants under changing climate and that can <u>better resist the biotic and abiotic stresses</u>.

Challenges Ahead……….

In rainfed areas (54 million ha worldwide), rainfall is the only source of water to the field and rice is grown only once a year (in the rainy season).

Due to unreliable rainfall distribution over the cropping season

Heavy downpour- most of the rainwater is lost from rice fields
or
Faces long dry spell, which results in low productivity.

It is also quite difficult to adopt any water-saving irrigation methods in rice cultivation in these areas during rainy season.

High costs of production, lower productivity (both crop and water), poor fertilizer use-efficiency and environmental pollution are common features of rainfed rice.

Integrated System of Rice Intensification (ISRI)

Rice -SRI method

Excess rainwater conserved in the refuge/pond- Used for supplementary irrigation.

The stored water in the pond - growing fish for short-term periods, and the refuge bunds were used for horticultural crops

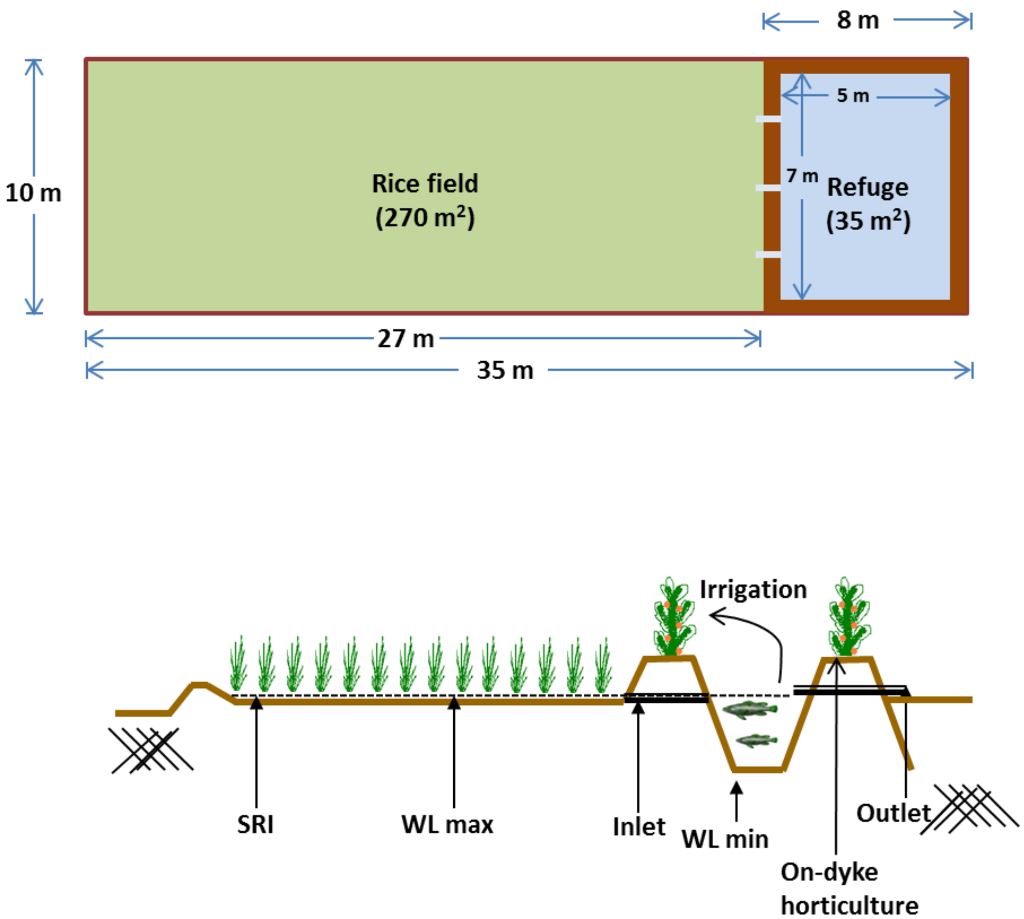
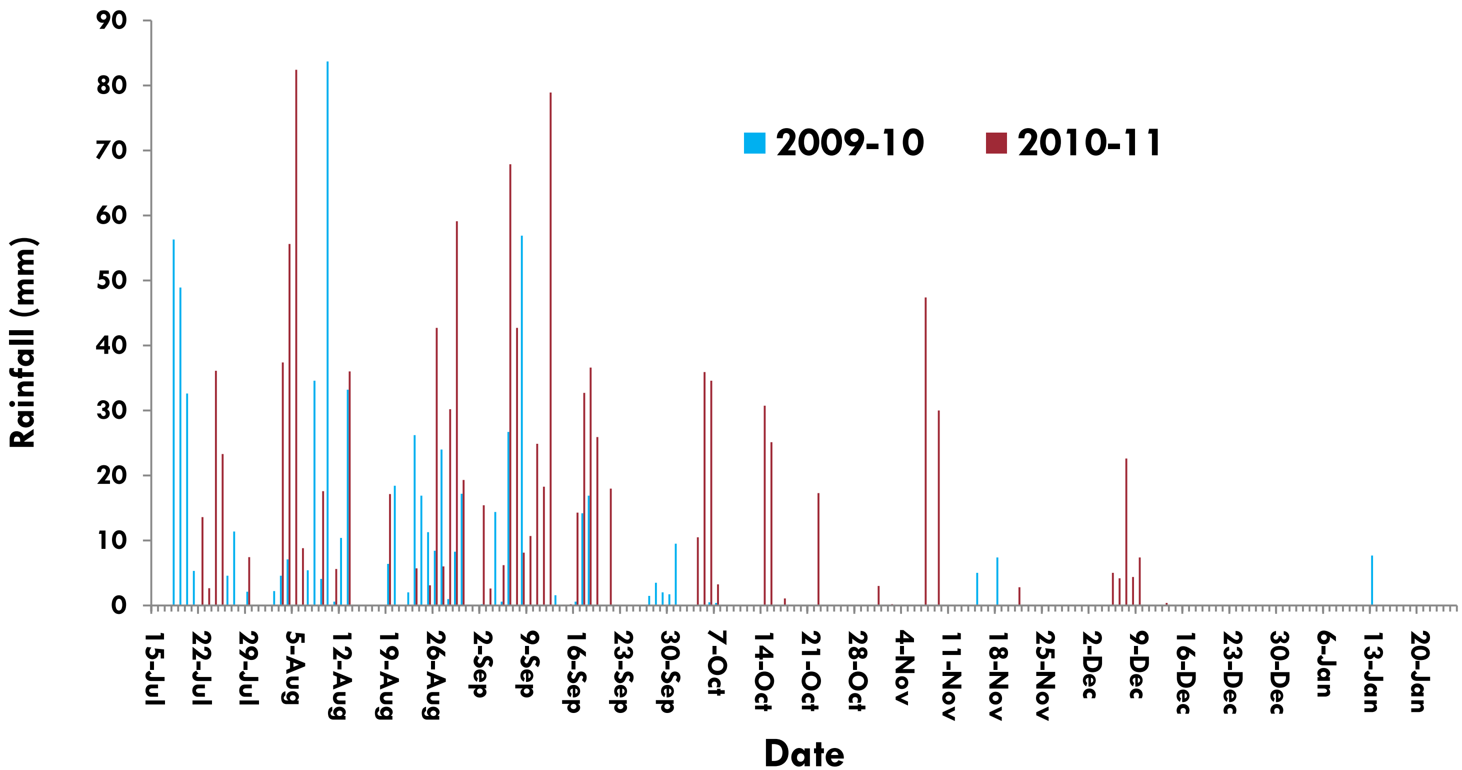


Fig. 1. Lay-out Design of Integrated System of Rice Intensification

Experimental details

Treatments for rice crop management	Symbols	Cropping system
Rice crop was grown with conventional method , and all rainwater was harvested and used in the field without any supplemental irrigation	C-RW	Rice only
Rice crop was grown with SRI methods and all rainwater was harvested and used in the field without any supplemental irrigation	S-RW	Rice only
Rice crop was grown with SRI methods, no stagnant water was kept in the field (excess rainwater was drained) and supplemental irrigation was provided as and when required	S-IW	Rice only
Rice crop was grown with SRI methods, no stagnant water was kept in the field (excess rainwater was stored in the refuge) and supplemental irrigation was provided from water conserved in the refuge as and when required	S-CW	Rice + Fish + Horticultural crops

Daily Rainfall Pattern



Rainfall during the entire rice crop period (July-November) : 650.9 mm (2009) and 1155.1 mm (2010)

Grain yield

Rice production system	Grain yield (t ha^{-1})		
	2009	2010	Mean
C-RW	2.36 g	3.41 f	2.89 d
S-RW	4.21 e	4.61 d	4.41 c
S-IW	5.96 b	5.43 c	5.70 b
S-CW	6.22 a	6.09 b	6.16 a
Year			*
Treat			**
Y x T			**

	% increase	Reason
C-RW vs S-RW	52%	SRI practices except WM, NM
S-RW vs S-IW	29%	Proper WM
S-IW vs S-CW	8%	Use of nutrient rich irrigation water

Grain yield

Rice production system	Grain yield (t ha^{-1})		
	2009	2010	Mean
C-RW	2.36 g	3.41 f	2.89 d
S-RW	4.21 e	4.61 d	4.41 c
S-IW	5.96 b	5.43 c	5.70 b
S-CW	6.22 a	6.09 b	6.16 a
Year			*
Treat			**
Y x T			**

% increase in S-RW (Rainfed-SRI) compared with C-RW (Rainfed-Conv)	
2009 (Drought year)	78
2010 (Normal rain)	35

% increase in S-IW compared with C-RW (Rainfed-Conv)	
2009 (Drought year)	152
2010 (Normal rain)	59

% increase in S-CW (ISRI) compared with C-RW (Rainfed-Conv)	
2009 (Drought year)	163
2010 (Normal rain)	78

Root growth & activity (Early grain-filling stage)

Rice production system	Root dry weight (g $hill^{-1}$)			Root dry weight (g m^{-2})		
	2009	2010	Mean	2009	2010	Mean
C-RW	3.4 d	4.7 d	4.1 d	176.3 e	236.2 c	206.3 c
S-RW	7.0 c	8.6 bc	7.5 c	172.3 e	201.2 d	187.0 d
S-IW	10.5 b	9.9 b	10.2 b	262.2 b	246.3 bc	254.3 b
S-CW	12.7 a	11.9 ab	12.3 a	317.8 a	298.2 a	308.0 a
Year			ns			ns
Treat			**			**
Y x T			ns			ns

	% increase (Hill basis)	% change (Area basis)
C-RW vs S-RW	82%	-9%
S-RW vs S-IW	36%	36%
S-IW vs S-CW	20%	21%

Drought

Conventional method - Grain yield reduction more

% increase in grain yield under SRI-Greater

Under SRI-difference between drought and normal rainfall year- not as big as in conv. method

SRI-DROUGHT tolerant

Mainly due to greater roots

***Reduced plant densities* – leads increases in root development - can be a simplest strategy to alleviate the risks of unreliable rainfall**

Morpho-physiological improvement

Phenotypic improvements in SRI plants included:
✓plant height,
✓greater tillering,
✓more number of leaves, and
✓expanded root systems.

Improvements in physiological functions like,
✓greater xylem exudation rate,
✓higher light interception by the canopy,
✓more chlorophyll content,
✓greater light utilization, and
✓higher photosynthetic rates in the leaves during flowering under SRI was recorded.

Grain-filling severely affected during drought year

Economic Analysis & Water Productivity (2-years)

Rice production system [a]	Cost of cultivation (CC) (Rs.)	Output value (OV) (Rs.)	Net profit (Rs.)	OV:CC ratio	Water used (m^3)	Net water productivity (Rs. m^{-3})
C-RW	1183.0	1336.0	153.0	1.13	487.6	0.31
S-RW	1155.0	2468.7	1313.7	2.14	487.6	2.69
S-IW	1355.0	3189.2	1834.2	2.35	661.5	2.77
S-CW [b]	4782.1	14183.0	9401.0	2.97	497.2	18.91

[a] Area of the each replicated plots was 350 m^2.

[b] In S-CW system, out of 350 m^2 area- 270 m^2 was used for rice cultivation, 35 m^2 was refuge area used for fish culture and rest 45 m^2 area was under bund used for horticultural crops

Conclusion

- Improved morph-physiological characteristics under SRI were responsible for improvement in yield-contributing characteristics and for higher grain yield (52%) compared with conventional production methods under rainfed condition.

- All of these features along with grain yield and water productivity further improved by providing drainage and supplementary irrigation to the crop.

- Further, integrating aquaculture and horticulture with SRI management, utilizing harvested rainwater, increased rice productivity, net water productivity and net income per unit of water used. Integrated SRI has potential to greatly improve water productivity.

- The profuse, deeper, and more functional root-systems of SRI plants are able to cope with flooding/drought stresses.

- Reduced plant densities under SRI, leading to remarkable increases in root development, are seen to alleviate the risks of unreliable rainfall, while leading to increased grain yields.

Take home points

- ***SRI increase the resilience of rice cultivation system because of more robust and healthy plants with strong tillers and the profuse and deeper root systems. These phenotypic alterations under SRI method make plants more tolerant to short periods of water stress associated with droughts conditions, less vulnerable to heavy rainfall and storm damage.***

- ***Apart from enhanced grain yield, water productivity and significantly higher economic return, ISRI also helps to cope rice crop from unreliable rainfall due to climate change.***

Thanks

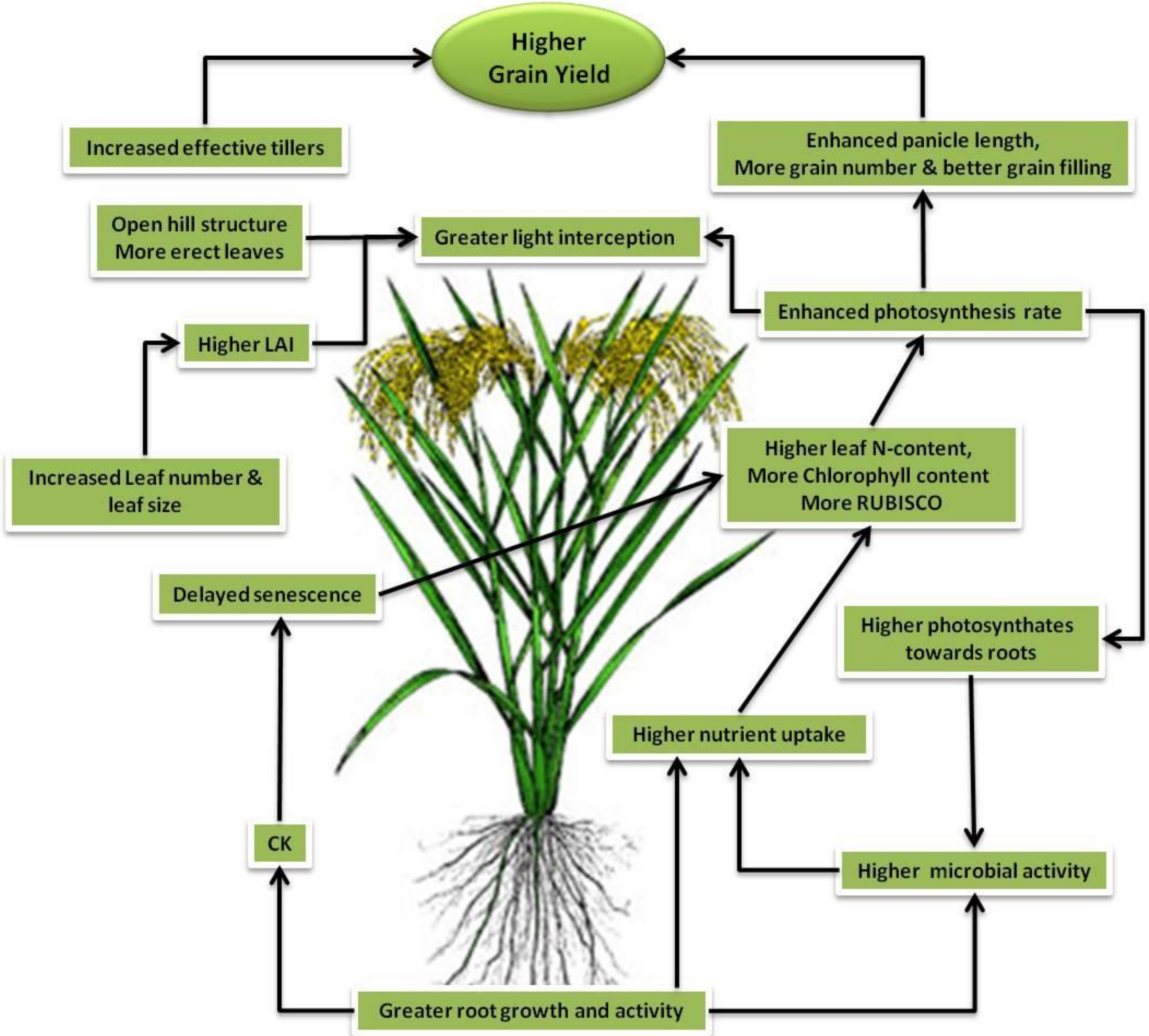


Fig. 1 A schematic model showing factors that may be responsible for higher grain yield of rice plant grown under SRI management practices. (CK: Cytokinins; LAI: Leaf area index; RUBISCO: Ribulose-1,5-bisphosphate carboxylase/ oxygenase)