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Productivity and economics of rice (*Oryza sativa*) in system of rice intensification in North-Western Himalayas

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ABSTRACT

A field experiment was conducted at Malan during *kharif* 2006 and 2007 to evaluate the productivity and profitability of rice under system of rice intensification (SRI) and integrated crop management (ICM). The SRI involved transplanting of 10-12 days old single seedling/hill at 25 cm x 25 cm; ICM involved transplanting of 15-18 days old 1-2 seedlings/hill at 20 cm x 20 cm spacing and were compared with conventional transplanting (CT) of 4 weeks old 2-3 seedlings/hill at 20 cm x 10 cm spacing. The treatments (CT, SRI, ICM) were tested in 2 sets,1 with same date of nursery sowing (consequently with different transplanting dates) and another with same date of transplanting (with different dates of nursery sowing). The SRI and ICM methods outperformed CT under same date of nursery sowing. The plants under SRI and ICM were taller by 7.4 cm and 6.1 cm, respectively and matured 7 days earlier compared to CT (124 days). More tillering at hill level compensated and thus effective tillers/m^2 in ICM (247) were at par with CT (244) but were less in SRI (203). Panicle weight (g) was significantly more in SRI (3.75) followed by ICM (3.01) and CT (2.85). On an average ICM (6.67 t/ha; 14.5%) and SRI (6.43 t/ha; 10.6%) produced significantly more grain yield compared to CT (5.81 t/ha). NPK uptake was significantly more in ICM (98.9, 19.6, 96.8 kg/ha) followed by SRI and CT. On an average, ICM recorded significantly higher net return (Rs 40,943/ha) and benefit:cost ratio (2.04) followed by SRI (Rs 39,120/ha and 1.98). Under same date of nursery transplanting, the number of effective tillers/m^2 were significantly less under SRI (164) and ICM (214) and so the productivity and profitability in new methods was less. Thus, it is concluded that under mid hills of Himachal Pradesh, ICM was promising to increase the productivity and profitability of transplanted rice.

Key words: Crop management, Economics, Intensification, Productivity, Rice

The system of rice intensification (SRI), a new method of transplanted rice culture was developed in 1983 by Father Henri de Laulanie in Madagascar. However, the method attracted attention in other countries only after 1997. Uphoff (2003) reported SRI to comprise of 3 basic concepts: transplanting young seedlings, at wider spacing in square pattern and keeping the soil moist and aerated during vegetative phase. Later Rajendran *et al.* (2004) suggested some modifications in SRI to suit the local needs and named the new package as integrated crop management (ICM) which means integrated use of compatible best management practices/technologies to increase the productivity and income (Balasubramanian *et al.*, 2005). These methods aim to exploit the younger seedlings potential of higher productivity. The proponents of SRI/ICM have claimed substantial increases in rice productivity (Balasubramanian *et al.*, 2007; Sinha and Talati, 2007) in different rice growing areas. However, reduced yields under SRI have also been reported (McDonald *et al.*, 2006). Keeping aside the controversies and inadequate scientific insight, the present investigation was undertaken to explore the possibility of using younger seedlings and harnessing the associated advantages in crop productivity, crop duration and economizing the inputs particularly the seed under high rainfall areas of Himachal Pradesh.

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MATERIALS AND METHODS

A field experiment was conducted at Rice and Wheat Research Centre of CSK Himachal Pradesh Krishi Vishvavidyalaya, Malan (32^{0}1´E, 76^0 2´N and 950 m above mean sea level, average annual rainfall 1,900 mm) during *kharif* 2006 and 2007, to study the rice performance in SRI and ICM in comparison to conventional transplanting (CT) method. The experimental soil was silty clay loam in texture and acidic in reaction (pH 5.7) having 403 kg available N, 15 kg available P and 186 kg K/ha and 0.46% organic carbon. The 3 methods (CT, SRI and ICM) in 2 sets, one with same date of nursery sowing (9 June in

2006 and 14 June in 2007; consequently with different transplanting dates under different treatments) and another with same date of transplanting (7 July in 2006 and 10 July in 2007; consequently with different dates of nursery sowing), were tested in randomized block design with 3 replications using medium duration rice cultivar 'HPR 2143'. SRI involved planting of 10-12 days old single seedling/hill at 25 cm × 25 cm; ICM involved transplanting of 15-18 days old 1-2 seedlings/hill at 20 cm × 20 cm spacing in comparison to CT of 4 weeks old 2-3 seedlings/hill at 20 cm x 10 cm spacing.

Nursery for SRI involved preparation of 4-5 cm raised beds with soil and FYM (2:1) on which seed was uniformly spread. The bed was then covered with rice straw for 2-3 days and kept moist by sprinkling water frequently. The seed requirement in this method is 5 kg/ha. Seedlings were not traditionally uprooted but taken out along with soil, without disturbing the root system.

Seedlings for ICM were raised through modified mat nursery (MMN). The soil mix was prepared by mixing 75-80% soil, 15-20% well decomposed farmyard manure, and 5% rice hull converted to ash. The firm nursery area was leveled and divided into 1.2 m wide beds. A black sheet was spread over the beds. A wooden frame of 0.5m length, 1.0 m width and 0.04 m depth having 4 equal segments was placed over the plastic sheet. The frame was then filled with soil mix almost to the top. Pre-sprouted seeds were sown uniformly, covered with the soil mix and firmed gently with hand followed by soaking by sprinkling water. The wooden frame was then removed carefully. The seed bed was kept moist by sprinkling water as and when required. In MMN, 100 m^2 nursery area and 10 -12 kg seed is required for transplanting 1 ha area. The date on which seed was put in water for soaking, was the same as the date of nursery sowing in CT and SRI. Soaking was done for 24-36 hours, and seed was wrapped in gunny bags for 24 hours to get the sprouts.

Each plot received fertilizer dose @ 34–13–25 kg N–P–K/ha and 10 tonnes FYM/ha (0.52% N, 0.22% P and 0.56% K) at the time of last puddling. Next day on well leveled plot, transplanting was done. Weeds in SRI and ICM were managed by incorporating them into the soil twice at 10 and 20 days after transplanting (DAT) with the help of cono weeder. Additionally, the use of cono weeder helped in the aeration of soil. In CT, Butachlor granules were applied 3-5 DAT @ 1.5 kg a.i./ha. Hand weeding was also done wherever some weeds appeared to keep the crop free from weeds. Nitrogen (@ 17 kg) was top dressed at maximum tillering and panicle initiation stages. Water saving component as being claimed by various workers was ignored as the area receives high rainfall. In *kharif* 2006 and 2007, 1,914 and 1,109 mm rainfall was received in 67 and 57 rainy days, respectively. In SRI and ICM plots 1 - 4 cm water was allowed to stand during reproductive stages whereas during vegetative stages water was applied to keep the soil moist particularly before the onset of monsoons or excess water was allowed to drain out whenever intense rains occurred. Data on the performance of crop were recorded. Nine hills were selected randomly to compute the number of effective panicles/unit area. Five panicles were selected randomly to compute the panicle weight and number of grains/panicle. Nutrient accumulation by the crop was estimated by multiplying the nutrient concentration with the grain/straw yield. In 2006, soil samples were collected at flowering for microbial records of heterotrophic bacteria, fungi and phosphorus solubilizing bacteria. The cost of cultivation and returns were calculated by taking into account the prevailing cost of inputs and prices of output.

RESULTS AND DISCUSSION

Productivity under same date of nursery sowing

Both the test methods viz., SRI and ICM influenced the performance of rice favourably (Tables 1 and 2). These methods recorded significantly higher grain yield during both the years. On an average ICM (6.67 tonnes/ha) and SRI (6.43 tonnes/ha) produced 14.5 % and 10.6% more grain yield compared to CT (5.81 tonnes/ha). The productivity enhancement due to these methods corroborate well with those of Balasubramanian *et al.* (2005) and Sinha and Talati (2007).

The better performance of the crop under SRI and ICM was the outcome of enhanced growth measured in terms of plant height, hastened development and maturity (6-7 days early flowering/maturity), improved yield attributes and yield (Table 1). Pooled data revealed that the crop in SRI and ICM was taller by 7.4 cm and 6.1 cm, respectively. Vijayakumar *et al.* (2006) also reported taller plants with younger seedling (14 days old) than with CT. The younger seedlings in SRI and ICM when carefully transplanted by keeping the roots straight (assuring that the roots do not assume 'J' shape) might have encouraged vigorous and deeper root system which in turn resulted into more vigorous and taller plants. Besides the control of weeds, the use of cono weeder might have been associated to improved aeration as has been emphasized by different proponents of SRI (Makarim *et al.*, 2002; Uphoff, 2003) resulting in increased crop vigour in the present study. The transplanting of younger seedlings reduces transplanting shock to the seedlings and hence advances the tillering process (LinHua *et al.*, 2006). This advantage is carried over by the crop and thereby encouraging its early maturity. In the present investigation, days taken by the crop to come into 50% flowering were significantly reduced and these were on an average less in SRI and ICM by 7 and 6 days and also maturity by a week.

The number of hills in CT were 50/m^2 whereas these were 50% (25/m^2) under ICM and almost one-third (16 m^2) under SRI due to the wider spacing under new methods. The increased tillering at the hill level compensated and thus resulted in statistically same number of panicles/m^2 in ICM (247) as in CT (244) but not in SRI (203). The spacing of 25 cm x 25 cm for SRI appears too wide in North-Western hills as the medium duration varieties grown in the hills have only limited time for tillering. Sharma and Masand (2008) reported that increased tillering at hill level was offset by wider spacing, so SRI recorded less number of tillers/unit area.

The panicle size was larger under the new methods and number of grains/panicle were significantly more in SRI (130) and ICM (113) than CT (94) as observed by Sharma and Masand (2008). Pooled mean revealed significantly more panicle weight under SRI (3.75 g) followed by ICM (3.01 g) and CT (2.85 g). So, heavier panicle was primarily responsible for accrued advantages in productivity under these methods in comparison to CT. These results are in agreement with those of Vijayakumar *et al.* (2004). The test weight of the rice crop is least affected by the treatments as the grain is tightly enclosed in hulls. Pooled data under the present investigation revealed the similar trend.

Table 1. Plant height, days taken to 50% flowering and maturity, yield attributes (pooled) and yield (t/ha) as influenced by different methods of rice culture

Treatment	Plant height (cm)	Days to 50% flowering	Days to maturity	Panicles/ m^2	Panicle weight (g)	Test weight (g)	Grain yield		Biological yield	
							2006	2007	2006	2007
Same date of nursery sowing										
CT	111.1	87	124	244	2.85	26.7	5.80	5.83	12.15	12.37
SRI	118.5	80	117	203	3.75	26.2	6.80	6.07	14.54	12.43
ICM	117.2	81	117	247	3.01	25.7	6.94	6.38	15.00	13.04
Same date of transplanting										
CT	113.6	86	123	250	2.87	26.8	5.93	5.85	12.20	12.20
SRI	111.2	81	118	164	3.23	25.9	5.81	4.53	12.30	9.77
ICM	110.8	84	120	214	2.58	26.3	5.69	4.70	12.04	10.96
SEm±	1.59	0.5	0.6	6.1	0.09	0.38	0.09	0.06	0.18	0.10
CD (P=0.05)	4.93	1.4	2	19	0.28	NS	0.29	0.18	0.57	0.31

Table 2. Microbial population, nutrient uptake, net returns and benefit:cost as influenced by different methods of rice culture

Treatments	Microbial population			Nutrient uptake (kg/ha)			Cost of cultivation (Rs/ha)	Net returns** (Rs/ha)		Benefit : Cost	
	HB (x10^5 CFU/g)	Fungi (x10^3 CFU/g)	PSB (x10^1 CFU/g)	N	P	K		2006	2007	2006	2007
Same date of nursery sowing											
CT	65.7	6.0	8.3	86.6	17.1	84.9	19,350	33,699	34,156	1.74	1.76
SRI	54.3	7.7	8.0	95.4	18.8	92.6	19,700	42,900	35,341	2.18	1.79
ICM	189.7	14.3	31.0	98.9	19.6	96.8	20,050	44,116	37,771	2.20	1.88
Same date of transplanting											
CT	72.7	5.3	11.0	86.6	17.2	83.7	19,350	34,084	34,316	1.78	1.76
SRI	62.3	6.7	7.7	77.1	15.0	76.6	19,700	22,151	27,892	1.71	1.12
ICM	198.6	21.3	40.7	79.7	15.7	80.4	20,050	24,571	28,376	1.61	1.22
SEm±	5.5	1.8	1.7	0.7	0.2	0.7		475	440	0.04	0.03
CD (P=0.05)	16.9	5.6	5.2	2.2	0.7	2.2		1,475	1,368	0.12	0.08

*HB: Heterotrophic bacteria, **price of paddy grains Rs 7,500/t and price of straw Rs 1,500/t

The plants were taller under new methods and more tillering at hill level made the crop to record significantly more biological yields and thus straw yield under ICM (7.36 tonnes/ha) followed by SRI (7.05 tonnes/ha) and CT (6.44 tonnes/ha). So, despite wider spacing, the farmers get higher straw yield, which is traditionally fed to the animals.

The better performance of SRI and ICM crop under the common date of nursery is also attributed to the earlier transplanting date which might have exposed the crop to better temperature conditions particularly at reproductive stage as low temperature here in hills becomes a limiting factor (Sharma and Prasada Rao, 2004).

The microbial analysis performed at the harvest of crop in 2006 revealed higher population of heterotrophic bacteria (189.7 x 10^5 CFU/g), fungi (14.3 x 10^3 CFU/g) and phosphorus solubilizing bacteria (31.0 x 10^1 CFU/g) particularly under ICM (Table 2). Significant variations among the nutrient uptake were observed mainly due to the variation in the grain and straw yield of the crop. The uptake of the nitrogen, phosphorus and potassium was significantly more under ICM (98.9, 19.6, 96.8 kg/ha) followed by SRI (95.4, 18.8 and 92.6 kg/ha) over CT (86.6, 17.1, 84.9 kg/ha).

Productivity under same date of transplanting

The plant height in SRI (111.2 cm) and ICM (110.8 cm) was statistically at par with CT (113.6 cm) under common date of transplanting (Table 1). However, the days taken to 50% flowering in SRI (81) and ICM (84) were less than CT (86). The moderate increase in tillering at hill level could not offset the wider spacing (25 cm x 25 cm /20cm x 20 cm) under new methods and thus significantly less panicles/m^2 were recorded in SRI (164) and ICM (214). However, the number of grains/panicle (119) and panicle weight (3.23 g) were significantly more under SRI. The nutrient (N, P and K) uptake was significantly more under CT (86.6, 17.2, 96.8 kg/ha, respectively). The grain and biological yield in SRI and ICM was significantly less than CT in 2007 (Table 1). The reduction in grain yield was 12.2% in SRI and 11.8% in ICM. Results are in conformity with that of Mc Donald *et al.* (2006). However, it was noticed that the count of heterotrophic bacteria, fungi and phosphorus solubilizing bacteria, determined at the harvest of rice crop was higher in ICM (Table 2).

Economics

The seed rate used under SRI (5 kg/ha) is one-sixth when compared with CT and that of ICM (10-12 kg/ha) is one-third than that of CT (30 kg/ha) resulting in valuable resource saving such as seed under these newer methods. The monetary saving from this resource becomes 8-10-fold in case of hybrid seed. Though, transplanting under SRI and ICM is done at wider spacing, but young seedlings require careful handling and hence almost similar time for transplanting as under CT. Management of weeds through cono weeder under these methods is also more expensive compared to chemical weed control in CT. The cost of cultivation in CT, SRI and ICM was Rs 19,350, 19,700 and 20,050/ha, respectively, although Reddy *et al.* (2006) have reported lower cost of cultivation under SRI. The higher grain and straw yield under the new methods under common date of nursery, recorded higher mean net returns (Rs 40,943/ha) and benefit:cost ratio (2.04) in ICM followed by SRI (Rs 39,120/ha and 1.98). Whereas, the net returns and benefit:cost ratio under same date of transplanting in CT, ICM and SRI were Rs 34,316, Rs 27,892 and Rs 28,376/ha and 1.77, 1.42 and 1.42, respectively.

Thus, ICM involving raising healthy nursery through MMN and transplanting 15-18 days old 1-2 seedlings/hill at 20 cm x 20 cm during second fortnight of June, is recommended to increase the productivity and profitability of transplanted rice under mid- hill conditions of Himachal Pradesh.

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