Comparative evaluation of SRI with conventional system in the irrigated rice tracts of Kerala

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Abstract

An experiment was conducted to assess the performance of rice under the system of rice intensification (SRI) in comparison with the conventional system of cultivation. The field studies were carried out during the rabi seasons of 2007 and 2008 in the lateritic sandy clay loam soils of RARS, Pattambi, Palakkad district in Kerala, having pH 5.00 and medium fertility, in RBD with 16 treatments replicated thrice. The weed density and dry weight were higher in SRI. Growth parameters such as plant height, number of tillers hill^{-1} and dry matter production hill^{-1}, and yield parameters like number of productive tillers hill^{-1} and length of panicle were significantly higher in the SRI treatments, whereas the tiller density, dry matter production per unit area, the grain yield per hectare and the B:C ratio were higher in the conventional system. Hence it is concluded that in the irrigated rice tracts of Kerala conventional system of rice cultivation is more advantageous than the SRI in terms of crop yield and economics of cultivation.

Key Words: System of Rice Intensification (SRI), Conventional system, Weed density & dry weight, Cono weeding, Tiller count, Tiller density.

Introduction

Rice has been cultivated sustainably for centuries through scientifically well defined and accepted management technologies and inputs. As a deviation from this, system of rice intensification (SRI), a set of certain management practices in rice cultivation derived from the work of a French Jesuit priest, Fr. Henri de Laulanie´ in Madagascar during the 1980s, is reported to offer increased productivity of rice with limited inputs (Laulanie, 1993). SRI management involves many departures from the methods conventionally recommended for rice cultivation. These management practices include: (a) transplanting younger seedlings, (b) widely spaced transplanting with one seedling hill^{-1}, (c) application of compost or other organic amendments, (d) intermittent irrigation up to panicle initiation (PI) followed by keeping shallow water in the field, and (e) intensive manual and mechanical weed control starting from 10 days after transplanting and continuing until the canopy closes (Uphoff, 2002).

SRI technology has been debated for its pros and cons and the advocates of SRI claim higher yields with limited resources (Batuvitage, 2002; Stoop et al., 2002). Yield increase to the tune of 2 to 6 t ha^{-1} has been reported in SRI in Madagascar (Uphoff, 2002) and there are reports from various locations in India claiming 16 to 32 per cent yield advantage over the conventional system (Viraktamath, 2007; Sinha and Talati, 2007). ICRISAT-WWF (2008) reported a yield increase of 9.3 to 68 per cent in SRI compared to the conventional practice. Yield increase in SRI over traditional method has also been reported by Hussain et al. (2003), Batuvitage (2006), Krishna et al. (2008), Mao et al. (2008) and Geethalaksmi et al. (2011).

On the other hand, many criticisms have been raised against the assessed yield superiority in the system

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of rice intensification over the conventional best management practices, the reliability of reported super high yields and the applicability in large scale rice farming systems (McDonald et al., 2006; Senthilkumar et al., 2008).

In the above circumstances, the present study was undertaken with an objective to study the weed problems and the feasibility of system of rice intensification in the irrigated rice growing agro-ecological situation in the Kerala state, in comparison with conventional system of rice cultivation.

Materials and Methods

The experiment using the rice cultivar Jyothi (110 to 120 days) was conducted during the Rabi seasons of 2007 and 2008 in the lateritic sandy clay loam soils of Regional Agricultural Research Station, Pattambi in Palakkad district of Kerala. The soil is with pH 5.00 and medium fertility. The area enjoys tropical monsoon climate with more than 80 per cent rainfall distributed through south-west and north-east monsoon showers.

The experiment was laid out in randomized block design (RBD) with 16 treatments, replicated thrice in plots of 20 m^2 gross area.

- T1 SRI with four cono weedings at 10, 20, 30 and 40 days after transplanting (DAT)
- T2 SRI with pre-emergence herbicide followed by one hand weeding at 30 DAT
- T3 SRI with pre-emergence herbicide followed by one cono weeding at 30 DAT
- T4 SRI with two cono weedings at 10 and 30 DAT
- T5 SRI with one cono weeding at 10 DAT followed by one hand weeding at 30 DAT
- T6 SRI with one cono weeding at 10 DAT followed by post emergence herbicides
- T7 SRI with post emergence herbicides alone
- T8 SRI with four cono weedings at 10, 20, 30 and 40 DAT + organic manure alone (the typical SRI)
- T9 Conventional system (CS) with four cono weedings at 10, 20, 30 and 40 DAT
- T10 CS with pre-emergence herbicide followed by one hand weeding at 30 DAT
- T11 CS with pre-emergence herbicide followed by one cono weeding at 30 DAT
- T12 CS with two cono weedings at 10 and 30 DAT
- T13 CS with one cono weeding at 10 DAT followed by one hand weeding at 30 DAT
- T14 CS with one cono weeding at 10 DAT followed by post emergence herbicides
- T15 CS with post emergence herbicides alone
- T16 CS with two hand weedings at 20 and 40 DAT (Normal POP)

Note: As pre-emergence herbicide, butachlor @1.25 kg ha^{-1} (Hiltaklor 50 EC) was used. Post emergence treatment included Cyhalofop butyl @ 0.1 kg ha^{-1} (Clincher 10% EC) at 18 DAT followed by Almix 20% WP @ 4.0 g a.i. ha^{-1} (Metsulfuron methyl 10% + Chlorimuron ethyl 10%) at 20 DAT.

In SRI, 10 day old single seedlings were transplanted at 30 cm x 30 cm spacing while in the conventional system (CS), 20 day old seedlings (two each) were transplanted at 20 cm x 10 cm spacing. In the conventional system, water management was done as per the package of practices recommendations (KAU, 2007) whereas in SRI, as it specifically limits the use of water, just enough irrigation was done to get the soil saturated and subsequent irrigation was given as and when the soil developed fine cracks. This irrigation schedule was followed till the crop completed its tillering phase, and thereafter standing water at a height of 2.5 cm was maintained in the field. Vermicompost (1.5% N, 0.4% P_2O_5, 1.8% K_2O) (KAU, 2007) was used as the organic manure, and chemical fertilizers, urea (46.1% N), rajphos (20% P_2O_5) and muriate of potash (60% K_2O) were used to supply N, P and K respectively. Cono weeding was done perpendicularly in two directions in the SRI field while in the conventional system, it was done in between the rows only.

Observations on crop growth parameters, yield attributes, yield and weeds were recorded. Cost of cultivation was worked out taking into account the prevailing labour charge in the locality, cost of inputs and the extra treatment costs and expressed in Rs. ha^{-1}. The gross return was calculated based on the local market prices of paddy and straw, and expressed on per hectare basis. Benefit: cost ratio (B: C ratio) was calculated using the formula:

$$\text{B: C ratio} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

The pooled mean data were subjected to analysis of variance using the Statistical Package for Social Sciences (SPSS), Version 16.0 and the comparison among treatment means was done by the Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Differential response of the growth parameters viz., plant height, number of tillers and dry matter accumulation at different growth stages of rice was noticed in the two systems of cultivation. In the initial phase, plant height was higher in all the treatments under the conventional system, whereas towards the later growth phase significantly taller plants were observed under SRI treatments (Table 1). Optimum age of the seedlings combined with closer spacing in the conventional system might have boosted the height of rice during the vegetative phase. The 20 day old seedlings transplanted under conventional system had already advanced by 10 days in growth as compared to the 10 day old seedlings under SRI, and this advancement in growth might have helped the seedlings to compete for better resources, attaining more height in the early growth phase in the conventional system. Higher plant height under conventional system compared to SRI has been reported earlier by Mankotia et al. (2006). In SRI, the plants were showing more lateral growth rather than vertical growth in the initial growth phases through production of more number of tillers $hill^{-1}$. The increased height towards the later reproductive phase in SRI compared to conventional system may be due to the wider spacing which would have helped in better availability of resources and increased photosynthesis, resulting in better growth. Higher number of functional leaves, more leaf area and higher number of tillers $hill^{-1}$ at wider spacing increased the photosynthetic rate leading to taller plants (Shrirame et al., 2000).

Table 1. Effect of treatments on growth parameters of rice at different growth stages

Treatments	Plant height, cm			Tiller no. $hill^{-1}$			Tiller no. m^{-2}			Dry matter, t ha^{-1}		
	Active tillering	PI stage	Harvest	Active tillering	PI stage	Harvest	Active tillering	PI stage	Harvest	Active tillering	PI stage	Harvest
T1 - SRI + CW-10, 20, 30, 40 DAT	41.97^{b} *	59.87^{bcd}	70.87^{ab}	9.57^{cd}	15.17^{bc}	22.48^{a}	106.3^{c}	168.5^{c}	249.8^{c}	0.32^{f}	11.07^{ef}	3.40^{ef}
T2 - SRI + Pre-H + HW-30 DAT	45.14^{b}	56.71^{d}	72.17^{a}	8.87^{cd}	16.08^{bc}	24.04^{a}	98.6^{c}	178.7^{c}	267.1^{c}	0.29^{f}	1.63^{de}	3.3^{ef}
T3 - SRI + Pre-H + CW- 30 DAT	42.36^{b}	57.93^{d}	70.87^{ab}	8.83^{cd}	16.73^{b}	24.67^{a}	98.1^{c}	185.9^{c}	274.1^{c}	0.21^{f}	1.50^{ef}	2.85^{f}
T4 - SRI + CW- 10, 30 DAT	41.61^{b}	59.23^{bcd}	71.10^{ab}	10.61^{bc}	13.43^{c}	18.84^{b}	117.9^{c}	149.3^{c}	209.3^{c}	0.40^{f}	0.95^{f}	3.34^{ef}
T5 - SRI + CW- 10 DAT + HW-30 DAT	43.80^{b}	57.76^{cd}	70.30^{a}	12.04^{b}	16.74^{b}	23.44^{a}	133.7^{c}	185.9^{c}	260.4^{c}	0.44^{f}	2.15^{cd}	4.62^{d}
T6 - SRI + CW-10 DAT + Post-H	42.06^{b}	60.10^{bcd}	71.93^{ab}	10.63^{bc}	16.60^{b}	24.67^{a}	118.1^{c}	184.4^{c}	274.1^{c}	0.49^{f}	1.110^{ef}	4.57^{d}
T7 - SRI + Post-H	43.62^{b}	60.07^{bcd}	67.97^{ab}	8.20^{d}	17.73^{b}	22.37^{a}	91.1^{c}	197.0^{bc}	248.5^{c}	0.39^{f}	1.38^{ef}	2.88^{f}
T8 - SRI + CW-10, 20, 30, 40 DAT + OM	51.44^{a}	66.52^{a}	72.17^{a}	23.14^{a}	22.53^{a}	21.49^{ab}	257.1^{b}	250.4^{b}	238.7^{c}	1.37^{e}	2.57^{c}	4.42^{de}
T9 – CS + CW-10, 20, 30, 40 DAT	53.06^{a}	61.63^{abcd}	66.32^{b}	7.56^{c}	9.00^{d}	9.14^{c}	377.7^{a}	450.0^{a}	457.1^{b}	3.82^{ab}	4.55^{ab}	10.36^{a}
T10 – CS + Pre-H + HW-30 DAT	51.89^{a}	61.97^{abc}	69.40^{ab}	8.57^{cd}	9.17^{d}	10.73^{c}	428.4^{a}	458.3^{a}	536.7^{ab}	2.97^{d}	4.18^{b}	9.39^{ab}
T11 – CS + Pre-H + CW- 30 DAT	50.10^{ab}	61.37^{bcd}	66.25^{b}	7.63^{d}	9.07^{d}	10.22^{c}	381.3^{a}	453.3^{a}	510.8^{ab}	3.68^{abc}	4.52^{ab}	9.82^{ab}
T12 – CS + CW- 10, 30 DAT	53.08^{a}	61.48^{bcd}	66.18^{b}	7.72^{d}	9.37^{d}	9.42^{c}	385.8^{a}	468.3^{a}	470.8^{ab}	3.71^{abcc}	4.66^{ab}	10.13^{a}
T13 – CS + CW- 10 DAT + HW-30 DAT	54.07^{a}	62.25^{abc}	65.82^{b}	7.92^{d}	8.73^{d}	9.72^{c}	395.8^{a}	436.7^{a}	485.8^{ab}	3.35^{bcd}	4.35^{ab}	7.86^{c}
T14 – CS + CW-10 DAT + Post-H	53.13^{a}	61.90^{abc}	66.32^{b}	7.85^{d}	8.50^{d}	10.21^{c}	392.2^{a}	425.0^{a}	510.4^{ab}	3.24^{cd}	4.33^{ab}	8.92^{bc}
T15 – CS + Post-H	53.03^{a}	62.37^{abc}	68.48^{ab}	8.14^{d}	9.27^{d}	11.21^{c}	406.8^{a}	463.3^{a}	560.4^{a}	4.04^{a}	4.88^{a}	9.30^{ab}
T16 - CS + HW – 20, 40 DAT	54.63^{a}	63.63^{ab}	66.95^{ab}	7.66^{d}	8.60^{d}	9.66^{c}	382.8^{a}	430.0^{a}	482.9^{ab}	3.59^{abc}	4.46^{ab}	7.98^{c}

*In a column, means with the same superscript do not differ significantly at 5% level (in DMRT)
SRI- System of rice intensification; CW- Cono weeding; OM- Organic manure; DAT – Days after transplanting; herbicide
CS – Conventional system; HW – Hand weeding; Pre-H : Pre emergence herbicide; Post-H: Post emergence

The number of tillers hill^{-1} was significantly higher in all the SRI treatments. The typical SRI (T8) produced 23.14, 22.53 and 21.49 tillers hill^{-1} at active tillering, panicle initiation (PI) and harvest stages, respectively, while conventional system with normal POP (T16) produced only 7.66, 8.60 and 9.66 tillers hill^{-1} at the respective stages. Significantly higher number of tillers hill^{-1} in the SRI treatments may be the result of wider spacing wherein all the tiller buds, including that of secondary and tertiary tillers, get favourable environment to grow and express their identity. Wider spacing reduces inter-plant competition for nutrients, water, light, and air, which accounts for significant enhancement in the performance of individual hills under SRI (Thakur et al*.,* 2010). XuHui et al. (2006) have reported that SRI might improve the environment of individual plants, enhance their production potential, increase the rooting ability, and increase tillers hill^{-1}. The intermittent wet and dry soil condition unique to SRI might have energized the tillering potential of plants under SRI. It is natural that standing water reduces tillering. In SRI, there was no standing water in the field, resulting in well aerated soil condition favouring better tillering. Shad (1986) and Uphoff (2001) reported that not only wider spacing but limited irrigation as well as mechanical weeding also contributed to increased tiller density hill^{-1} in SRI through increased soil aeration and root pruning.

Even though the number of tillers hill^{-1} was higher in the SRI treatments, the tiller count from unit area was significantly higher in treatments with conventional system, at all the stages of observation. This was reflected in the dry matter production ha^{-1} also as it was the highest in the conventional system throughout the crop growth period (Table 1). The typical SRI produced 257, 250 and 234 tillers m^{-2} at active tillering, PI and harvest stages, respectively, while the conventional system with two hand weedings produced 383, 430 and 483 tillers m^{-2} at the respective stages. Increased density of rice plants in response to narrower spacing was reflected in higher tiller density and dry matter production per unit area in the treatments under conventional system. SRI field with wider spacing of 30 cm x 30 cm could accommodate only 11-12 plants m^{-2} while conventionally transplanted field with narrower spacing of 20 cm x 10 cm could accommodate 50 plants m^{-2}. A higher dry matter production per unit area in the conventional treatment compared to SRI might also be due to the greater plant density under conventional system as reported by Latif et al. (2005). Profuse tillering and highest tiller number hill^{-1} under wider spacing and highest number of effective tillers m^{-2} under narrower spacing have been reported by Kumar et al. (2006). Islam et al. (2005), Sindhu (2008) and Thakur et al. (2009) also reported reduction in tiller density per unit area with increase in plant spacing. Further, Mankotia et al. (2006) reported higher mean number of tillers per unit area under conventional method compared to SRI, and Thakur et al. (2011) attributed this to greater number of hills per unit area under conventional method.

Major weeds observed in the experimental field were *Isachne miliacea* (grass); *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliacea*, *Schoenoplectus lateriflorus* (sedges); *Sphenoclea zeylanica*, *Ludwigia perennis* and *Dopatrium junce*um (broad leaf weeds). Observation on weed growth showed higher occurrence of weeds in the system of rice intensification compared to the conventional system. The values of weed density and weed dry weight were higher in the SRI plots (Table 2). Higher weed competition under SRI compared to the conventional system can be attributed to the congenial environment enjoyed by the weeds through wider plant spacing (Mertens and Jansen, 2002) and aerobic soil condition (Singh et al., 2010). Sindhu (2008) also reported significant reduction in the number and dry matter production of weeds with an increase in plant density under closer spacing.

The data show that cono weeding, even in SRI, cannot control the weeds efficiently. The weed

Table 2. Effect of treatments on root characteristics of rice at panicle initiation stage and weeds at 45 days after transplanting

Treatments	Root length (cm)	Root dry weight (g hill^{-1})	Weed density (Number m^{-2})	Weed dry weight (g m^{-2})
T1 - SRI + CW-10, 20, 30, 40 DAT	17.75^{bc*}	1.36^{de}	10.22^{a} (104.0)**	3.43^{de} (11.27)
T2 - SRI + Pre-H + HW-30 DAT	16.87^{bcd}	1.80^{bc}	4.10^{e} (16.33)	0.81^{i} (0.18)
T3 - SRI + Pre-H + CW- 30 DAT	14.50^{de}	1.67^{bcd}	3.84^{ef} (14.33)	1.34^{gh} (1.30)
T4 - SRI + CW- 10, 30 DAT	18.43^{abc}	1.13^{efgh}	11.11^{a} (123.0)	6.21^{a} (38.13)
T5 - SRI + CW- 10 DAT + HW-30 DAT	20.75^{a}	2.03^{b}	11.06^{a} (122.0)	1.49^{fgh} (1.73)
T6 - SRI + CW-10 DAT + Post-H	16.50^{cd}	1.30^{ef}	5.78^{d} (34.67)	3.53^{de} (11.96)
T7 - SRI + Post-H	16.65^{cd}	1.65^{cd}	6.25^{cd} (38.67)	3.08^{de} (8.97)
T8 - SRI + CW-10, 20, 30, 40 DAT + OM	19.50^{b}	2.17^{a}	7.76^{b} (60.00)	4.64^{c} (21.15)
T9 – CS + CW-10, 20, 30, 40 DAT	11.90^{efg}	1.24^{efg}	5.51^{d} (30.00)	5.26^{b} (27.28)
T10 – CS + Pre-H + HW-30 DAT	10.55^{fg}	0.98^{fghi}	1.47^{gh} (2.00)	1.16^{hi} (0.88)
T11 – CS + Pre-H + CW- 30 DAT	9.33^{g}	0.92^{ghi}	3.66^{ef} (13.33)	3.65^{d} (12.87)
T12 – CS + CW- 10, 30 DAT	12.42^{ef}	1.04^{efghi}	7.47^{bc} (55.33)	4.54^{c} (20.13)
T13 – CS + CW- 10 DAT + HW-30 DAT	11.28^{fg}	0.84^{hij}	0.71^{h} (0.00)	0.71^{i} (0.00)
T14 – CS + CW-10 DAT + Post-H	10.10^{fg}	0.50^{i}	3.89^{ef} (14.63)	1.77^{fg} (2.83)
T15 – CS + Post-H	11.85^{fge}	0.73^{ij}	2.65^{fg} (6.67)	1.92^{f} (3.27)
T16 - CS + HW – 20, 40 DAT	12.42^{ef}	0.79^{hij}	1.65^{gh} (2.22)	1.01^{hi} (0.69)

*In a column, means with the same superscript do not differ significantly at 5% level (in DMRT)

** $\sqrt{x + 0.5}$ transformed, original values in parentheses

SRI- System of rice intensification; CW- Cono weeding; OM- Organic manure; DAT – Days after transplanting; CS – Conventional system; HW – Hand weeding; Pre-H : Pre emergence herbicide; Post-H: Post emergence herbicide

density as well as weed dry weight in the SRI plots were significantly reduced through the application of herbicides, either post emergence or pre emergence. Cono weeding could remove the weeds in the inter-row spaces alone retaining the one in and around the individual rice hill (Fig.1). Similar results have already been reported by Kavitha et al. (2010) with pre-emergence herbicides and Sindhu (2008) with post-emergence herbicides.

Studies on yield parameters showed that SRI treatments performed significantly better in terms of number of productive tillers hill^{-1} and length of panicle, but the percentage of filled grains and thousand grain weight did not differ between the two systems (Table 3). In contrast, the number of productive tillers per unit area was significantly higher under the conventional system. The SRI treatments produced 18.5 to 23 productive tillers

Figure 1. Escaped weeds near the rice hill after cono weeding

hill^{-1} compared to 8.64 to 10.66 by the conventional treatments, while per unit area it was 432 to 533 m^{-2} in the conventional system as against 206 to 263 m^{-2} in the SRI (Table 3).

Significant increase in certain yield attributes of individual rice plant under the SRI may be due to the increased vigour of plants because of higher root growth and the related nutritional benefits, combined with reduced inter-plant competition because of wider spacing. In the present study the values of root length and dry matter were found significantly higher in SRI when compared with the conventional system (Table 2). Development of more number of productive tillers hill^{-1} under SRI has been reported by Nissanka and Bandara (2004), whereas at narrower spacing higher number of productive tillers m^{-2} due to an increased plant density per unit area has been reported by Bommayasamy et al. (2010). Thakur et al. (2010) reported significant improvement in the performance of individual hills under wider spacing in terms of panicle number, panicle length, grain number panicle^{-1} and grain filling. Greater root length density and higher rate of root activity have been reported to affect the yield contributing parameters in SRI (Mishra and Salokhe, 2011). Increase in panicle length and grain number panicle^{-1} under SRI have been reported by Rahman et al. (2006) and Kumar et al. (2006). Increased number of filled grains panicle^{-1} has been attributed to an increased dry matter translocation percentage from vegetative organs to the grains as reported by Wang et al. (2002). Akobundu and Ahissou (1985) observed decreased number of tillers and panicles hill^{-1} as inter-row distance was reduced.

Significant variation in grain yield of rice was noticed between the two methods of planting. The highest grain yield in the experiment was recorded in the conventional system i.e. 2877 kg ha^{-1} in T15, which was followed by T12 (Table 3). The typical SRI and all other SRI treatments produced significantly lower grain yield even with significantly longer panicles. A reduced number of productive tillers per unit area combined with increased weed incidence and associated nutrient removal in SRI might be the reason that can be attributed to this phenomenon. Significant increase in grain yield in the conventional treatments might

Table 3. Effect of treatments on yield attributes and economics of rice cultivation

Treatments	Productive tillers (No. hill^{-1})	Panicle length (cm)	Filled grains (%)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T1 - SRI + CW-10, 20, 30, 40 DAT	21.95^{ab*}	20.11^{ab}	87.39^{a}	1883^{fg}	1908^{cdef}	28268^{de}	-11018^{h}	0.72^{g}
T2 - SRI + Pre-H + HW-30 DAT	23.59^{a}	20.47^{a}	82.06^{b}	2475^{bcde}	2295^{ab}	36946^{abc}	-3840^{efg}	0.91^{def}
T3 - SRI + Pre-H + CW- 30 DAT	23.63^{a}	20.51^{a}	82.59^{ab}	1609^{g}	1941^{bcdef}	24472^{e}	-11764^{h}	0.68^{g}
T4 - SRI + CW- 10, 30 DAT	18.50^{b}	20.01^{abc}	80.83^{b}	1869^{fg}	2269^{abc}	28439^{de}	-8047^{gh}	0.78^{fg}
T5 - SRI+ CW-10 DAT+HW-30 DAT	22.17^{a}	20.51^{a}	82.17^{b}	2511^{abcd}	2231^{ab}	37387^{abc}	-4349^{fg}	0.90^{ef}
T6 - SRI + CW-10 DAT + Post-H	23.20^{a}	20.39^{ab}	83.13^{ab}	2338^{de}	2510^{a}	35246^{c}	-2420^{cdef}	0.94^{de}
T7 - SRI + Post-H	21.73^{ab}	20.38^{ab}	80.17^{b}	2285^{de}	2170^{abcde}	34160^{c}	-1056^{bcdef}	0.97^{cde}
T8 - SRI +CW-10,20,30,40 DAT+OM	21.32^{ab}	20.54^{a}	83.04^{ab}	2168^{ef}	2470^{a}	32817^{cd}	-3268^{defg}	0.91^{def}
T9 – CS + CW-10, 20, 30, 40 DAT	8.64^{c}	18.61^{de}	80.31^{b}	2418^{cde}	2001^{bcde}	35850^{bc}	1864^{bcd}	1.05^{bcd}
T10 – CS + Pre-H + HW-30 DAT	10.30^{c}	18.76^{de}	81.96^{b}	2812^{ab}	2043^{bcdef}	41417^{ab}	4431^{ab}	1.12^{b}
T11 – CS + Pre-H + CW- 30 DAT	9.75^{c}	18.78^{de}	82.80^{ab}	2356^{de}	1974^{bcdef}	34959^{c}	1748^{bcde}	1.05^{bcd}
T12 – CS + CW- 10, 30 DAT	9.18^{c}	18.73^{de}	82.46^{ab}	2858^{ab}	1933^{bcdef}	41940^{a}	9354^{a}	1.29^{a}
T13 – CS+ CW-10 DAT+HW-30DAT	8.99^{c}	19.85^{abc}	82.22^{b}	2788^{abc}	1879^{def}	40910^{ab}	4199^{ab}	1.11^{bc}
T14 – CS + CW-10 DAT + Post-H	9.55^{c}	19.05^{cde}	83.21^{ab}	2567^{abcd}	1828^{ef}	37766^{abc}	3125^{bc}	1.09^{bc}
T15 – CS + Post-H	10.66^{c}	19.38^{bcd}	83.62^{ab}	2877^{a}	2042^{bcdef}	42322^{a}	8906^{a}	1.27^{a}
T16 - CS + HW – 20, 40 DAT	9.08^{c}	18.25^{e}	81.56^{b}	2600^{abcd}	1755^{f}	38157^{abc}	671^{bcdef}	1.02^{bcde}

*In a column, means with the same superscript do not differ significantly at 5% level (in DMRT)

SRI- System of rice intensification; CW- Cono weeding; OM- Organic manure; DAT – Days after transplanting; CS –Conventional system; HW– Hand weeding; Pre-H: Pre emergence herbicide; Post-H: Post emergence herbicide be because of the higher dry matter production, uptake of nutrients and number of panicles per unit area. Kumar et al. (2006) reported higher panicle length, grain number $panicle^{-1}$ and 1000 grain weight under SRI, but they were not significantly reflected in the yield. Balachandran and Louis (2007), Joseph et al. (2009) and Anitha and Chellapppan (2011) attributed the higher grain yield under the conventional system to higher number of productive tillers consequent to higher plant population per unit area.

As against the grain yield, the yield of rice straw was the highest (2510 kg ha^{-1}) in the SRI treatment T6 followed by the typical SRI (T8), which were at par. All the treatments in the conventional system recorded significantly lower values of straw yield per hectare. The plants in SRI were producing tillers of secondary or tertiary nature even during the late vegetative phase. It is assumed that the inputs needed for grain formation might have been diverted for production of these late formed unproductive tillers in SRI, leading to lower grain yield while adding to the straw yield alone.

SRI is said to be a low input rice cultivation system but, as is evidenced from the data on the economics of rice cultivation in the two systems (Table 3), higher B:C ratio was obtained in the conventional system. This was because of the higher labour charges for weed control by cono weeding, without proportionate increase in the grain yield, as SRI with post emergence herbicides recorded a better B:C ratio that was on par with the cono weeded plots in the conventional system. This points out that when we opt for SRI it is better to adopt weed control through post emergence herbicides rather than cono weeding so as to get higher B:C ratio. In the present study the weed density and weed dry weight in the SRI plots were significantly lower with herbicides than with cono weeding (Table 2). Similar results have already been reported by Sindhu (2008).

The study showed that the system of rice intensification (SRI) resulted in better performance of individual plants, but a lower population density owing to wider spacing hindered its reflection in the grain yield per unit land area when compared to the dense conventional system. Heavy incidence of weeds in SRI exaggerated this situation. Also, a relentless formation of unproductive tillers in SRI increased the straw yield alone at the expense of grain yield. Hence it is concluded that conventional system of rice cultivation with recommended package of practices is more advantageous over the system of rice intensification in the irrigated tracts of Kerala in terms of growth parameters, yield and economics of cultivation. Further, the results also point out to the possibility of using herbicides for effective weed control in SRI wherever the system is feasible.

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* Original not seen.