Indian Journal of Hill Farming 27(1):106-110 Available online at www.kiran.nic.in

Productivity and Economic Performance of *Sali* Rice under System of Rice Intensification and Integrated Crop Management as Influenced by Weed Management Practices

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Received 16.5.2014, Revised 28.6.2014, Accepted 30.6.2014

ABSTRACT

Rice productivity in North East India is low mainly due to poor agronomic practices and cultivation of local low yielding tall varieties. An intervention was made at Sibbari cluster of South Garo Hills district of Meghalaya during *kharif* 2010 and 2011 to evaluate the weed management practices for system of rice intensification (SRI) and integrated crop management (ICM) method of rice establishment for higher productivity and income. Results revealed that minimum weed density (6.05/m^2), weed dry weight (10.15 g/m^2) and higher weed control efficiency (64.15 %) was obtained under ICM as compared to conventional rice culture (CRC). Minimum weed density (3.03), weed dry weight (4.66 g/m^2) and higher weed control efficiency (83.71%) was observed under hand weeding twice at 20 and 40 days after transplanting (DAT) . Significantly higher plant height, effective tillers/hill, panicle length, test weight and grain yield of rice was obtained under SRI methods (4.63 t/ha) which was at par with ICM (4.58 t/ha) but remained superior to CRC. Hand weeding twice at 20 and 40 DAT gave higher growth and yield attributes and grain yield of rice. SRI fetched higher gross return (Rs. 55,560/ha). SRI method recorded comparatively higher gross return (Rs. 55,560/ha), net return (Rs.34, 526/ha) than ICM and CRC. Hand weeding twice at 20 and 40 DAT gave maximum gross return (Rs. 54,480/ha) and net return (Rs. 34,526/ha), whereas, B: C ratio was highest under cono- weeding at 20 and hand weeding at 40 DAT (2.59).

Keywords: Economics, Integrated Crop Management, Productivity, System of Rice Intensification, Weed management

INTRODUCTION

Rice (*Oryza sativa* L) being the staple food is grown in all possible locations and conditions. Weeds grow profusely in the rice fields and reduce crop yields drastically in transplanted rice. Especially at the time of peak period, the yield losses can be between 15-20 %, but in severe cases sometimes weeding is delayed due to labour crisis causing more than 50 % yield loss, depending upon the species, cultural practices and water availability in fields. Infestation of weed is one of the most important causes of grain yield loss of rice depending upon the nature and type of weeds and their intensity. Gasuapara Community Development Block (GCDB) of South Garo Hills district of Meghalaya, cultivate rice normally in an area of about 1177 hectare with the productivity of only 986 kg/ha which is much lower than the district productivity of 1053 kg/ha (Anonymous, 2008-09). The productivity of rice is very low due to traditional crop transplanting methods, use of long duration local varieties, imbalance fertilizer/manure application as well as lack of appropriate weed management practices. Majority of the area in GCDB is under hilly terrain with foot hills and valley lands where mostly *sali* (5.5 months) rice is grown under CRC (Close planting, 3-5 seedlings/ hill, 35-40 days seedling, random transplanting etc.). In traditional age old rice cultivation methods,

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farmers use 35-40 days old seedlings with 3-5in seedlings /hill which lead to increase insect pest infestation, diseases incidence and reduce the yield drastically. Since, rice is grown only with rain water and diversion of stream water, it is necessary to develop and introduce the resource conservation technology for improvement of *sali* rice productivity and income. Rice requires approximately 5000 litres of water to produce 1 kg of grains (Patel et al. 2008). In addition to the water shortage, non-availability of agricultural inputs like, seeds, fertiliser, labour, ploughing implements etc. increases the cost of cultivation. Even some farmers are giving up *sali* rice cultivation owing to its lower productivity and higher cost of cultivation. The poor farmers losing interest in rice cultivation as factor productivity is declining (Das et al. 2009) and its profitability is in question with the rise in input costs. In this context, new technologies like SRI and ICM appears to have potential that saves inputs, protects the environment and could improve productivity and soil health (Satyanarayana et al. 2006; Balasubramanian et al. 2007). The System of Rice Intensification SRI, developed in Madagascar over a 20-year period and synthesized in the early 1980s (Uphoff et al. 2002), offers opportunities to researchers and farmers to expand their understanding of potentials already existing in the rice genome. Experience with SRI methods suggests that average rice yields could be about double the present world average without replacement of cultivar or the use of purchased inputs (Wang et al. 2002). Of late, certain modifications in SRI has been suggested by IRRI scientists in Philippines named ICM to suit the local needs involving integrated use of best management practices to increase the productivity and income (Rajendran et al. 2005).

Hence, ICAR Research Complex for NEH Region, Umiam in collaboration with Krishi Vigyan Kendra (KVK), Tura has undertaken interventions on weed management practices on SRI and ICM in *sali* rice during *kharif* 2010 and 2011 to increase rice productivity and economic upliftment of farmers of South Garo Hills district of Meghalaya.

MATERIALS AND METHODS

A field intervention was undertaken during *kharif* 2010 and 2011 in farmers' field at Sibbari cluster, South Garo Hills, Meghalaya consisting eleven villages (Longitude 25°01'08" to 25°10' 55" N and Latitude 90°26'00" to 90° 30'29" E with altitude of 11-32 m above MSL). The mean annual rainfall is about 2000 mm with average 77 rainy days. The dry season lasts for about six months of the year from November to April. The average minimum temperature is about 26°C while the average maximum temperature is about 36°C. The field level intervention was laid out in randomised block design consisting of two transplanting method viz., SRI and ICM and three weed management practices *viz*., Hand weeding (HW) at 20 and 40 DAT, Cono-weeding at 20 and 40 DAT and Cono-weeding at 20 DAT+ HW at 40 DAT, control (no weeding) and replicated four times with the total treatments of twenty five including farmers' practice. The methodology for rice transplanting demonstrated which involves 10 days old seedlings at 1 seedling/ hill was transplanted in square system with 25 x 25 cm spacing under SRI and 20 days old seedlings at 2 seedlings/hill in 20 x 20 cm spacing under ICM method. The seeding rate is 5-10 kg/ha, compared to 50-100 or more kg/ha in CRC. Farmers tend to flood their fields with excess water whenever they get the opportunity to do so, because they believe that rice does better under flooded conditions. Rice grown under traditional practices requires approximately 700 to 1,500 mm of water, 60-80% of which is required from transplanting to maturity to meet the evapotranspiration demand and unavoidable seepage and percolation in maintaining a saturated root zone (Guerra et al. 1998). The recommended dose of 80 kg N/ha, 60 kg P/ha and 40 kg K/ha was applied in the form of urea, single superphosphate and muriate of potash. Nitrogen 50% and full dose of phosphorus and potassium were applied as basal. Remaining 25% of nitrogen was applied at active tillering stage and 25% at panicle initiation stage. The lowland rice variety Ranjit was used as test crop. Data on yield of rice was recorded both the years and pooled. Weed population was recorded using 0.25 m^2 quadrate and then converted into number of weeds/m^2 at 60 DAT in *sali* rice. The total weed density was calculated by the addition of monocot and dicot weed population and expressed as number/m^2. The data on weed dynamics were subjected to square root transformation v(x+0.5) to normalize their distribution (Gomez and Gomez 1984). The weeds were first sun dried and then dried at 70°C in hotair oven till a constant weight was obtained. The dry weight was recorded by using an electronic balance for both the season and pooled. The dry weight of weeds expressed in gram per square metre. The weed control efficiency was calculated by subtracting the dry weight of weeds in treated plot from dry weight of weeds in control plot and then divided by the dry weight of weeds in control plot multiplied by 100 and expressed as percentage. The yield attributes and yield of *sali* rice was recorded after harvesting and pooled. The cost of cultivation, gross return, net return and B:C ratios were calculated based on the prevailing market price of rice. Harvest Index (HI) was calculated as economic yield divided by biological yield multiplied by 100. The analysis of variance (ANOVA) was done in randomised block design for various observations (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Significantly higher weed density/m^2 was recorded under SRI at 60 DAT which was followed by CRC and ICM method (Table 1). The minimum dry weight of weeds per unit area was lowest when ICM method of transplanting was practiced followed by SRI and CRC. The highest weed control efficiency was recorded under ICM (64.51%) followed by SRI and CRC at 60 DAT stage. Significantly lower weed density was recorded with HW twice at 20 and 40 DAT which might be due to lower dicot weed population at 60 DAT. However, cono-weeding at 20 DAT + HW at 40 DAT was also statistically at par with cono-weeding twice at 20 and 40 DAT in terms of total weed density of *sali* rice (Table 1). It is noted that the trend of weed density was in descending order at the early stage of crop growth while HW twice at 20 and 40 DAT weeding drastically reduced weed density at the later stage of crop growth. Similar result was also reported by Pandey (2009) and Thapa and Jha (2002). Weed dry weights per unit area at all stages of observations in *sali* rice field was significantly influenced by weed management practices. The maximum dry weight of weed was noticed at control plot (no weeding) while the minimum under HW twice at 20 and 40 DAT which was at par with cono-weeding at 20 DAT + hand weeding at 40 DAT. This was in conformity with the results of Pandey (2009), Sanjay et al. (2006). Higher weed density and dry weight was recorded in control plot (Singh et al. 2008; Pandey 2009). The highest weed control efficiency (83.71%) was recorded at HW twice at 20 and 40 DAT and the lowest at control plot (0.00) which might be due to the fact that the weeds disappeared from 60 DAT to harvesting stage. The highest weed control efficiency with these treatments might be due to effective weed control resulting into lower weed biomass which resulted better weed control efficiency.

Table 1: Weed density, weed dry weight (60 DAT) and weed control efficiency in sali rice as affected by transplanting methods and weed management practices (pooled data of 2010 and 2011)

Treatments	Weed density (No./m^2)	Weed dry weight (g./m^2)	Weed control efficiency (%)
Transplanting methods			
System of rice intensification	8.84 (98.55)	14.11	43.67
Integrated crop management	6.05 (45.90)	10.15	64.51
Conventional rice culture	7.69 (58.15)	15.61	34.93
CD(P=0.05)	0.21	0.27	2.76
Weed management practices			
Hand weeding at 20 and 40 DAT	3.03 (8.96)	4.66	83.71
Cono-weeding at 20 and 40 DAT	9.23 (91.27)	14.70	48.60
Cono-weeding at 20 DAT+ Hand weeding at 40 DAT	8.14 (73.44)	11.60	59.44
Control	12.37 (154.13)	28.60	0.00
CD(P=0.05)	1.59	3.28	4.18

The weed data is subjected to square root transformation vx + 0.5.; Values within parenthesis indicates original values.

Significantly higher grain yield of rice was obtained under SRI methods (4.63 t/ha) which was at par with ICM (4.58 t/ha) but remained superior to CRC which might be due to conducive environment for rice to enhanced the growth, yield components and yield in SRI and ICM than farmers practice (Table 2). The higher grain, straw and biomass yield in SRI and ICM than CRC might be due to higher numbers of growth and yield attributes. The significant effect of different transplanting methods was observed on harvest Index, although maximum was being recorded with ICM (42.55%) being at par with SRI (42.35%). The

Table 2: Growth and yield attributes and yield of *sali* rice as influenced by transplanting methods and weed management practices (pooled data of 2010 and 2011)

Treatments	Plant height (cm)	Effective tillers /hill	Panicle length (cm)	Grains /panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Transplanting methods								
SRI	116.4	15.1	26.4	229.8	23.8	4.63	6.97	42.35
ICM	112.2	12.9	25.3	201.9	23.3	4.58	6.96	42.55
CRC	105.8	9.2	20.9	143.1	20.8	3.21	5.62	39.13
CD (*P*=0.05)	NS	NS	NS	NS	NS	0.03	NS	NS
Weed management practices								
HW at 20 and 40 DAT	117.7	16.6	24.2	201.2	25.2	4.54	6.26	41.39
Cono-weeding at 20 and 40 DAT	108.3	10.8	21.8	152.9	21.02	3.94	6.07	40.12
Cono-weeding at 20 DAT+ HW at 40 DAT	113.2	13.7	23.1	154.1	24.06	4.5	6.16	40.56
Control	101.2	8.3	19.7	123.5	19.76	2.6	4.98	38.17
CD (*P*=0.05)	3.24	3.3	2.16	2.41	1.26	0.14	0.14	NS

DAT: Days after transplanting

harvest index of a plant reflects the photosynthetic conversion from source to sink by improved nutrient uptake as well as proper utilization of nutrients for higher productivity of wetland rice. These finding were in corroboration with the findings of Thakur et al. (2010) and Balasubramanian et al. (2006). Significantly higher grain yield of wetland rice was obtained with hand weeding twice at 20 and 40 DAT (4.54 5/ha) which was statistically at par with cono-weeding at 20 DAT + HW at 40 DAT (4.48 t/ ha) but remained superior to control. This might be due to less weed infestation leading to higher yield components and yield compared to control. The higher grain yield of *sali* rice seems to be due to effective control of weeds, which reduced competition for light, nutrients and water, thereby enabling wetland rice to absorb more nutrients and other resources. Similar findings have been also reported by other researchers (Pandey 2009; Singh et al. 2008; Sanjay et al. 2006; Uphoff 2003). The highest harvest index (41.39%) was observed with HW and twice at 2040 DAT. On the other hand, inferior harvest index was recorded with control treatments (Table 2). Kiniry et al. (2001) reported that the values of rice harvest index varied greatly among cultivars, locations, seasons, and ecosystems, and ranged from 0.35 to 0.62, indicating the importance of this variable for yield simulation. Pandey (2009) reported that two HW produced the highest harvest index which was different from one hand weeding and unweeded check.

The cost of cultivation per hectare was comparatively higher for the CRC (Rs. 22,184/ha) than ICM (Rs. 21,195/ha) and SRI (Rs. 21, 0349/ ha). The reduction in cost of cultivation in SRI than ICM and farmers practice was mainly due to less seed rate requirement, nursery area, less fertilizer requirement, reduced weeding and irrigation. In case of weed management treatments, HW twice at 20 and 40 DAT (Rs 21,215/ha) required higher cost of cultivation per hectare while control plot required the lower cost of cultivation (Rs 17,450/ ha). Similar results were also reported by Pandey, (2009). SRI method recorded comparatively higher gross return (Rs. 55,560/ha) than ICM and farmers practice and lowest at control plot (Rs. 38,520/ha) during both the years and pooled. The analyzed data (Table 3) indicated that the higher net return was obtained with SRI transplanting method (Rs. 34,526/ha) followed by ICM and farmers practice. The higher return with SRI method might be due to higher yield and lower cost of cultivation compare to ICM and farmers practice. Among the weed management practices, the higher net return was recorded with hand weeding twice at 20 and 40 DAT and lowest at control plot during both the years and pooled. The maximum average benefit cost ratio was recorded in SRI transplanting method (2.64) followed by ICM (2.59) and the lowest were obtained in farmers' practice (1.74). The higher benefit cost ratio in SRI method might be due to higher gross return and lower cost of cultivation compared to ICM and CRC. On the other hand, the highest benefit cost ratio (2.59) was fetched by cono- weeding at 20 DAT + HW at 40 DAT followed by HW twice at 20 and 40 DAT and which might be due to lower cost of cultivation with higher gross return for cultivation of sali rice. This finding was in corroboration with the finding of Singh et al. (2008) and Pandey (2009).

Table 3: Economic performance of *sali* rice as influenced by transplanting methods and weed management practices (pooled data of 2010 and 2011)

Treatments	Cost of cultivation (Rs/ha)	Gross income (Rs./ha)	Net profit (Rs/ha)	B:C ratio
Transplanting methods				
SRI	21034	55560	34526	2.64
ICM	21195	54960	33765	2.59
CRC	22184	38520	16336	1.74
Weed management practices				
HW at 20 and 40 DAT	21215	54480	33265	2.57
Cono-weeding at 20 and 40 DAT	19262	47280	28018	2.45
Cono-weeding at 20 DAT+ HW at 40 DAT	20732	53760	33028	2.59
Control	17450	27120	9670	1.55

It could be concluded that under the existing agro-climatic conditions, the higher net return and benefit cost ratio could be achieved with SRI followed by ICM rice culture for *sali* rice in comparison to CRC practice. However, higher net return and benefit cost ratio was fetched with HW twice at 20 and 40 DAT but benefit cost ratio (2.59) with cono-weeding at 20 DAT + hand weeding at 20 DAT.

ACKNOWLEDGEMENT

The authors duly acknowledge the Indian Council of Agricultural Research, New Delhi for funding to undertake the study under the project “National Agricultural Innovation Project-3” at Sibbari cluster of South Garo Hills district of Meghalaya, India during 2007-14.

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