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ORIGINAL ARTICLE

Effect of age of Seedlings, weed and Nutrient Management practices on yield and yield attributes of rice under SRI

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ABSTRACT
Field experiments were conducted during wet season of 2010 and 2011 to study the effect of age of seedlings viz. 8, 12, 16 and 20 days old seedlings, two weed management practices (Cono and Mandua weeder) and three nutrient management practices viz. RDF (80:40:40 N:P_2O_5:K_2O kg ha^{-1}), 50% RDF + 10t FYM and 20t FYM in Odisha. Among the nutrient management practices the INM (50% RDF + 10t FYM) recorded tallest plant at harvest (120.1 cm), highest no. of tiller m^{-2} (351.6), highest LAI (6.46), dry matter accumulation (1003.4 g/m^{-2}), number of panicles m^{-2} (233.0) and test weight (23.0 g).The cono weeder and 12 days old seedling registered the highest values of plant height, number of tillers m^{-2}, leaf area Index, dry matter accumulation, number of panicles m^{-2} and test weight.. Among the age of seedlings 12 days old seedlings recorded highest grain yield (6574 kg ha^{-1}) and straw yield (7642 kg ha^{-1}). The nutrient supplement through INM and weed management by coco weeder registered highest grain yield 6415 kg $ha^{-1}$and 6348 kg ha^{-1}, respectively the gross returns (₹ 75479 ha^{-1}), net return (₹ 47519 ha^{-1}) and B : C ratio (2.71) were found maximum with 12 day old seedlings, the gross returns, net return and B : C ratio were found maximum with the cono weeder (₹ 73065 ha^{-1}, ₹ 44925 ha^{-1} and 2.61) respectively.
Key words: SRI, Age of seedling, Mandua weeder, Cono weeder, Nutrient, Rice

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INTRODUCTION

Rice (*Oryza sativa* L) is one important cereal crop which plays a key role in food security. More than 90% of total rice production in the world is consumed in Asian countries, where is a staple food for a majority of the population [8]. Rice is the principal staple food for 65% of the population of India. The demand for rice is expected to rise due to increase in population (1.6% $year^{-1}$) plus increased per capita incomes, while the area under rice cultivation is expected to reduce to 40 million ha in the next 15–20 years [17]. India is a predominantly rice growing country. Basing on the current rate of population growth (1.4%) and per capita consumption (215-230 g day^{-1}) the projected demand for rice by 2025 will be around 130 m tonnes. Rao et al., 2013 reported that about 3000-5000 litres of water is required to produce 1 kg of rice by conventional transplanting method of rice cultivation. The recently developed System of Rice intensification (SRI) method which decreases the use of inputs such as water and labour, is reported to have 20-30% higher or even more economic yield as compared to the conventional method of cultivation in India [3, 7]. In most of the cases planting at wider spacing of 25 cm X 25 cm reported to be the best under SRI method. Many workers are also in support of supplementation of nutrient from both the sources (inorganic + organic) in equal proportion to have higher crop production in one hand and the maintenance of soil quality on the other. Weeding with cono weeder is a usual practice in SRI method of rice cultivation. Sometimes it is experienced by many workers that the cono weeder is not working properly in all types of soil. Keeping this in mind the present study was designed.

MATERIAL AND METHODS

A field experiment was conducted at the Krishi Vigyan Kendra Instructional farm, Shyamakhunta, Mayurbhanj during wet season of 2010 and 2011. The soil of the experimental site was sandy clay loam in texture, acidic in reaction, low in organic carbon 0.46% and available N (221 kg ha^{-1}) but medium in available P (10.4 kg ha^{-1}) and potassium (139.3 kg ha^{-1}). The experiment was laid out in split plot design with three replication. The experiment comprising of four age of seedlings *viz*. 8, 12, 16 and 20 days old seedlings were randomised allotted in sub plots.

There are 24 number of treatment combinations in to with four age of seedlings (8,12,16 and 20 days old), two weed management practice (cono weeder & mandua weeder) and three nutrient management practices such as RDF (i.e. 80:40:40 N:P_2O_5:K_2O kg ha^{-1}), half RDF + half organic (10t FYMha^{-1}) and full organic (20 t FYM ha^{-1}). The six treatment combination of weed and nutrient management practices were randomised allotted in main plots and four age of seedlings were randomised within the sub plots. The rice variety *Pratikshya* was transplanted 25 cm X 25 cm spacing (single seedlings $hill^{-1}$). The same lay out plan was used to conduct the experiment in both the years. The manures and fertilizers were applied as per the treatments. The chemical fertilizers were applied through urea, diammonium phosphate and murate of potash and in the organic manures were applied through FYM. All the organic manures were incorporated immediately after layout of the experiment as per the respective treatments. Full dose of phosphorus and potassium and 50% of nitrogen were applied as basal and remaining nitrogen was top dressed twice i.e. 25% at active tillering stage and rest 25% at panicle initiation stage. Weeding was done thrice at 10-12 day intervals starting from 15 DAT using cono weeder and mandua weeder. Both the weeders were run carefully in a cris-cross pattern. The experimental plots were kept at saturation throughout the crop period. Studies on dry matter accumulation were carried out following the destructive sampling technique. Three hills from ear-marked second row of each plot were cut at the ground level. The samples were collected at 15 days interval starting from 30 DAT till maturity, air dried and subsequently oven dried at 70^oC for 72 hours to a constant weight. The dry weights were recorded in each plot and expressed as g m^{-2}.

RESULTS AND DISCUSSION

Table-1: Growth attributes influenced by age of seedlings,weeding and nutrient management under SRI.

Treatments	Plant height (cm) at harvest			Tillers m^{-2} at 75 DAT			Leaf area index at 75 DAT			Dry matter accumulation (g/m-2) at Harvest		
	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled
Nutrient management												
F_1	115.1	120.7	117.9	348.2	345.7	346.9	6.24	6.28	6.26	786.4	802.4	972.2
F_2	118.9	121.3	120.1	352.2	351.0	351.6	6.39	6.52	6.46	809.6	837.9	1003.4
F_3	112.3	117.2	114.8	333.6	337.0	335.3	6.01	6.13	6.07	708.2	711.0	832.1
SE m(±)	**1.57**	**1.08**	0.92	**4.71**	**2.52**	**3.68**	**0.08**	**0.07**	**0.12**	**8.4**	**8.5**	**5.4**
CD (0.05)	**4.96**	**3.40**	2.69	**14.84**	**7.93**	**10.79**	**0.26**	**0.22**	**NS**	**26.4**	**26.7**	**15.9**
Weed management												
W_1	117.7	121.3	119.5	352.4	347.6	350.0	6.33	6.44	6.38	793.0	809.8	965.8
W_2	113.2	118.2	115.7	337.0	341.5	339.2	6.10	6.18	6.14	743.1	757.8	906.0
SE m(±)	**1.29**	**0.88**	0.75	**3.85**	**2.06**	**3.01**	**0.07**	**0.06**	**0.10**	**6.9**	**6.9**	**4.4**
CD (0.05)	**4.05**	**2.78**	2.20	**12.12**	**NS**	**8.81**	**0.21**	**0.18**	**NS**	**21.6**	**21.8**	**12.9**
Age of seedlings (Days)												
8	116.9	121.3	119.1	351.3	349.3	350.3	6.17	6.23	6.20	829.7	861.8	1031.0
12	120.2	122.9	121.5	361.9	360.4	361.2	6.54	6.64	6.59	846.3	885.5	1040.6
16	113.2	120.6	116.9	344.4	342.9	343.7	6.20	6.40	6.30	710.0	709.4	855.5
20	111.5	114.3	112.9	321.1	325.4	323.3	5.94	5.98	5.96	686.3	678.4	816.6
SE m(±)	**1.73**	**1.30**	1.08	**4.81**	**5.29**	**3.58**	**0.08**	**0.09**	**0.06**	**7.2**	**6.6**	**5.2**
CD (0.05)	**4.96**	**3.72**	3.05	**13.80**	**15.17**	**10.08**	**0.23**	**0.26**	**0.17**	**20.7**	**19.1**	**14.8**

F_1-Full inorganic (RD:80:40:40 kg N:P_2O_5:K_2O ha^{-1}), F_2-Half RD +10t FYMha^{-1}, F_3-Full organic (20t FYM ha^{-1}) W_1-Cono weeder, W_2-Mandua weeder

Growth attributes

As per the pooled data of both the years transplanting of 12 days old seedlings recorded the highest value of all the growth attributes like plant height, number of tiller m^{-2}, leaf area index (LAI), dry matter accumulation (Table-1). The highest plant height from younger seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate increased cell division causing more stem elongation. Similar types of results were also

reported by Rahman, [20]; Vijaya kumar *et al.* [11]; Pramanik and Bera [10]. Rajendran *et al.* [12] observed that planting with two week old seedlings had maximum number of tillers followed by three, four and five week old seedlings. Krishna *et al.* [5] noted that rice seedlings transplanted before commencing the fourth phyllochron retained their higher tillering potential than that of seedlings of more than 14 days old. The higher LAI was might be higher number of tiller per unit area at 12 days old seedlings. This corroborated the earlier findings of Kavitha *et al.* [4]. Higher LAI and interception of more sunshine could be the reasons for higher dry matter accumulation and crop growth rate. Among the different nutrient management practices were significantly influenced the plant height, number of tillers m^{-2}, leaf area index, production of dry matter The pooled data revealed that the crop receiving the nutrient through 50% inorganic + 50% organic manure was found tallest plants (120.1 cm) than other nutrient management practices. The plant height was increased due to various physiological processes including cell division and cell elongation of the plant. The present results were in the line of earlier report Mandal and Adhikary [6] reported higher plant height with the treatment receiving 50% nitrogen through inorganic fertilizers and 50% through FYM followed by the treatments with 75% nitrogen through inorganic fertilizers and 25% through FYM. The present experiment revealed that the production of tillers significantly higher with the application 50% inorganic + 50% organic manure than other nutrient application and the increasing the tiller no upto 75 DAT after that it declined. Similar results reported by Mukherjee [9] the rate of mortality of tillers was more in higher dose of chemical fertiliser dose over relatively lower dose of chemical fertilizers with combination of organic manure. The lea area index was more when the rice crop grown with 50% inorganic + 50% organic manure and maximum LAI obtained at 75 DAT. San-oh *et al.* [15] also reported that the dry matter production of the canopy depends on its absorption of solar radiation, which is significantly affected by the LAI. The increased LAI in SRI was due to open plant structure giving more coverage to the ground area. Bhattacharyya *et al.* [1] reported that LAI at 60 days after transplanting (DAT) showed significantly highest value against cow dung manure + urea application. The study on different weed management practices were significantly influenced the plant height, number of tillers m^{-2}, leaf area index, production of dry matter, The higher growth parameters were found maximum when the weeds were controlled by cono weeder, it might be more eradicate of weeds, subsequently more incorporate weeds in soil, so that more available nutrients to the crop and also it might be better aeration of soil. Similar results were also reported by Surya Prava *et al*. [19].

Table-2: Yield attributes and yield of rice influenced by age of seedlings, weeding and nutrient management under SRI.

Treatments	Panicles m^{-2}			1000-grain weight (g)			Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index (%)		
	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled
Nutrient management															
F_1	222.8	225.6	224.2	22.6	22.8	22.7	6322	6378	6350	7676	7726	7701	45.1	45.2	45.2
F_2	231.4	234.5	233.0	22.8	23.3	23.0	6402	6429	6415	7439	7524	7482	46.2	46.0	46.1
F_3	203.1	206.0	204.6	22.1	22.2	22.2	5984	6005	5994	7515	7493	7504	44.3	44.5	44.4
SE m(±)	**4.4**	**3.3**	**2.68**	**0.17**	**0.23**	**0.14**	**109**	**101**	**72**	**51**	**59**	**45**	**0.4**	**0.3**	**0.3**
CD (0.05)	**13.7**	**10.4**	**7.87**	**0.53**	**0.73**	**0.40**	**345**	**318**	**212**	**160**	**186**	**131**	**1.4**	**1.0**	**0.8**
Weed management															
W_1	228.0	230.2	229.1	22.8	23.0	22.9	6340	6356	6348	7572	7657	7614	45.5	45.3	45.4
W_2	210.2	213.9	212.0	22.2	22.4	22.3	6131	6185	6158	7515	7505	7510	44.9	45.2	45.0
SE m(±)	**3.6**	**2.7**	**2.19**	**0.14**	**0.19**	**0.11**	**89**	**82**	**59**	**41**	**48**	**37**	**0.4**	**0.3**	**0.2**
CD (0.05)	**11.2**	**8.5**	**6.43**	**0.43**	**0.59**	**0.33**	**NS**	**NS**	**173**	**NS**	**152**	**NS**	**NS**	**NS**	**NS**
Age of seedlings (Days)															
8	229.2	231.2	230.2	22.6	23.1	22.9	6291	6346	6318	7538	7630	7584	45.5	45.4	45.4
12	236.0	238.4	237.2	22.9	23.3	23.1	6544	6605	6574	7598	7686	7642	46.2	46.2	46.2
16	212.8	217.4	215.1	22.4	22.4	22.4	6175	6219	6197	7640	7633	7636	44.7	44.9	44.8
20	198.4	201.2	199.8	22.0	22.2	22.1	5933	5912	5923	7398	7376	7387	44.5	44.5	44.5
SE m(±)	**3.1**	**3.8**	**2.47**	**0.20**	**0.21**	**0.15**	**49**	**53**	**36**	**61**	**69**	**46**	**0.3**	**0.3**	**0.2**
CD (0.05)	**8.9**	**11.0**	**6.96**	**0.57**	**0.61**	**0.41**	**140**	**152**	**102**	**174**	**197**	**129**	**0.8**	**0.8**	**0.5**

Yield attributes

The grown under SRI with different age of seedling under study exerted significantly influence on the yield attributes of rice (Table-2). From the present experiment, it was found that among the age of seedling were comparable to each other with respect to number of panicles m^{-2} and test weight, the 12 days old seedling recorded significantly the higher value of panicles m^{-2} (237.2) and test weight (23.1 g). This might be due to profuse root growth which helps in tillering, more tillering provides more photosynthesis to support root growth; both contribute to greater grain filling and larger grains. As per pooled data of both the years the rice plant receiving nutrients through 50% inorganic + 50% organic manure was recorded the highest number of panicles m^{-2} (233.0) and test weight (23.0 g). As per the pooled data the different weed management practices were significantly influenced the yield attributes The higher yield parameters were found maximum when the weeds were controlled by cono weeder, it might be more eradicate of weeds, subsequently more incorporate weeds in soil, so that more available nutrients to the crop and also it might be better aeration of soil. Similar results were also reported by Surya Prava *et al*. [19].

The pooled data of two years (Table-2) revealed that the nutrient supplement through 50% RDF + 50% FYM recorded the highest grain yield (6415 kg ha^{-1}) than that obtained from RDF (6350 kg ha^{-1}) and 100% FYM (5994 kg ha^{-1}). The treatment of nutrient through 50% inorganic + 50% organic increased grain yield by 7.1% over the full organic manure treatment. Similarly the harvest index was recorded highest with the treatment of INM, which was statistically higher than that obtained from RDF and 100% FYM. The latter two treatments were recorded at par harvest index. The straw yield was recorded highest with the treatment of RDF (7701 kg ha^{-1}), which was followed by 100% FYM and INM practice. The latter two treatments recorded at par straw yield. Rahman *et al.* [11] also reported that the application of organic manure and chemical fertilizers increased the grain and straw yields of rice. It is clear that organic manure in combination with inorganic fertilizers increased the vegetative growth of plants and thereby increased straw yield of rice. The increase in straw yield might be due to high N availability to the plants from an optimal source of inorganic might have supplied an adequate quantity of nutrients prominently the nitrogen, which usually promotes tillering, increases the plant height and dry matter accumulation becomes responsible for increase in straw yield [21]. The grain yield and straw yield and harvest index did not show any significant difference in both the years. When the rice crop grown with different age of seedlings had significantly influence on grain yield, straw yield and harvest index. As per the two years pooled data the rice crop transplanted at 12 days old seedlings found highest grain yield (6574 kg ha^{-1}), straw yield (7642 kg ha^{-1}) and harvest index (46.2%), which was found significantly higher than that obtained from 8, 16 and 20 days old seedlings in case of grain yield. The higher grain yield production in the younger seedlings might be attributed to the vigorous and healthy growth, development of more productive tillers and leaves ensuring greater resource utilization as compared to old age seedlings. The results also suggested that 10- days young seedlings resulted in highest increase in grain yield over 20- days and 30-days old seedlings. Similar results were reported by Pramanik and Bera [10].

Table- 3: Effect of age of seedlings, weeding and nutrient management under SRI on economics of rice production.

Treatments	Cost of cultivation (₹ ha^{-1})			Gros return (₹ ha^{-1})			Net return (₹ ha^{-1})			Benefit Cost ratio (₹ ha^{-1})		
	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled	2010	2011	pooled
Nutrient management												
F_1	26231	26340	26286	71254	75061	73158	45023	48721	46872	2.72	2.85	2.78
F_2	27825	27975	27900	71887	75449	73668	44062	47474	45768	2.58	2.70	2.64
F_3	29695	29695	29695	67645	70850	69248	37950	41155	39553	2.28	2.39	2.33
SE m(±)	-	-	-	**1134**	**1120**	**773**	**1134**	**1120**	**773**	**0.04**	**0.04**	**0.03**
CD (0.05)	-	-	-	**NS**	**3528**	**2267**	**3573**	**3528**	**2267**	**0.13**	**0.13**	**0.08**
Weed management												
W_1	28097	28183	28140	71358	74772	73065	43261	46589	44925	2.55	2.66	2.61
W_2	27737	27823	27780	69166	72802	70984	41429	44978	43204	2.50	2.63	2.56
SE m(±)	-	-	-	**926**	**914**	**631**	**926**	**914**	**631**	**0.03**	**0.03**	**0.02**
CD (0.05)	-	-	-	**NS**	**NS**	**1851**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Age of seedlings (Days)												
8	27917	28003	27960	70826	74642	72734	42909	46638	44774	2.55	2.67	2.61
12	27917	28003	27960	73481	77478	75479	45564	49474	47519	2.64	2.78	2.71
16	27917	28003	27960	69716	73274	71495	41799	45270	43535	2.51	2.63	2.57
20	27917	28003	27960	67025	69755	68390	39108	41751	40430	2.41	2.50	2.45
SE m(±)	-	-	-	**508**	**589**	**389**	**508**	**589**	**389**	**0.02**	**0.02**	**0.01**
CD (0.05)	-	-	-	**1457**	**1688**	**1096**	**1457**	**1688**	**1096**	**0.05**	**0.06**	**0.04**

Economics

The study on the economic feasibility of different age of seedlings on rice revealed that the gross returns (₹ 75479 ha^{-1}), net return (₹ 47519 ha^{-1}) and B : C ratio (2.71) were found maximum with 12 day old seedlings, as per pooled result (Table-3). Similar results were also reported by Reddy *et al*. [14], transplanting with 12 day old seedling at one seedling hill^{-1} under SRI recorded highest net profit (₹ 40773 ha^{-1}) and B:C ratio of 3.95. The gross returns were found higher with the treatment 50% inorganic fertilizer + 50% organic manure followed by 100% inorganic fertilizer, whereas the net returns were the highest with 100% inorganic fertilizer than 50% inorganic fertilizer + 50% organic manure. Less net return with the treatment of 50% inorganic fertilizer + 50% organic manure due to more expenditure incurred with FYM, but it improve the soil health. Similar results also found with B : C ratio. The favourable economic parameters obtained in case of 100% inorganic fertilizer and 50% inorganic fertilizer + 50% organic manure was mainly due to higher yields obtained in it as compared to the other two during both the years. Similar results were also reported by Singh *et al.* [18], Shekhar *et al.* [16] and Chandrapala *et al.* [2]. The gross returns, net return and B : C ratio were found maximum with the cono weeder (₹ 73065 ha^{-1}, ₹ 44925 ha^{-1} and 2.61) respectively (Table 3).

CONCLUSION

From the present investigations, it may be concluded that *kharif* rice needs to 12 days age seedlings with the application of 50% inorganic +5 t FYM ha^{-1} produced optimum growth attributes, yield attributes and productivity on sandy loam soils of North Central Plateau Agro-climatic Zone of Odisha.

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