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Crop establishment and weed management integration in rainfed medium land rice (*Oryza sativa* L.)

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Abstract
Field experiments were conducted during *kharif* season of 2013 and 2014 to find out the best crop management practice of rice (*Oryza sativa* L.). Among all the management practices, transplanting with post emergence application of bispyribac sodium 0.02 kg/ha at 21 days after sowing (DAS) followed by mechanical weeding at 35 DAS recorded the maximum value of plant height at harvest (129.7cm), leaf area index at 75 DAS (6.34), grains/panicle (131) and 1000-grain weight (29.58g), followed by drum seeding with same management practices. Transplanted rice recorded the maximum grain yield (4.64 t/ha), stover yield (5.56 t/ha) with maximum gross return of ₹ 67,771/ha and net return of ₹ 37,104/ha. Direct seeded rice in line (DSRL) with pre-emergence application of pendimethalin 1.0 kg/ha followed by one hand weeding at 35 DAS recorded the maximum return per rupee investment in rice (2.42) with grain yield and straw yield of 3.93 t/ha and 4.71 t/ha, respectively.

Keywords: Direct seeded rice sown in line (DSRL), transplanted rice, drum seeding, farmers practice of broadcasting, yield, economics

Introduction
Rice feeds about 50% of the world population and provides 19% of the global calories intake (IRRI, 2014) [8]. In India during 2015-16, rice was grown in an area of 43.50 million hectare area with a production of 104.41 million tonnes and productivity of 2400 kg/ha (MoA & FW, GOI, 2018) [10]. Rice is grown in an area of 4.17 million hectare with production of 8.30 million tonnes and productivity of 1992 kg/ha in Odisha. The productivity (1992 kg/ha) of rice in Odisha is much less compared to national average of 2391 kg/ha, USA average of 7500 kg/ha, Chinese average of 6500 kg/ha and Vietnam average of 5300 kg/ha. The productivity in Odisha is less due to several constraints viz. weed infestation, faulty method of crop establishment, disease and pest attack, low nutrient use efficiency and faulty water management. Crop establishment and weed management play major role in enhancing productivity of rice.

In Odisha, many farmers raise rice crop by transplanting of seedling under puddled condition. Puddling not only destroys the weeds, but also converts them into a very useful form of fertilizers (Wrigley, 1969) [16], breaks down soil aggregates, brings the finer particles into dispersed solution, subsequent settlement of clay particles and organic matter along with percolating water, clogging of subsurface micro pore result in lowering of percolation rate which reduces the water and nutrient losses and create favourable environment for rice growth (Ghildyal, 1978) [6]. It increases in availability of nutrients through reduction in cation (NH_4^+) leaching (Aggarwal *et al*., 1995) [1]. Puddling is labour intensive and requires huge amount of water. Raising seedlings, puddling of field, followed by transplanting involve high labour cost and fossil fuels. Transplanting after puddling is associated with various constraints like late planting due to non availability of water and labour at peak time which causes low plant population and ultimately reduction in yield. At the same time, field preparation by puddling results in alteration of soil physical properties, which adversely affects the succeeding crops (Gangwar *et al*., 2008) [5]. The area under transplanted rice is decreasing due to scarcity of water and labour. So there is need to search for alternate crop management practices to increase the productivity of rice (Farroq *et al*., 2011) [4]. Direct seeded rice in lines is alternative to transplanting, due to elimination of preparation of nursery, puddling of main field for transplanting, saves labour and involves less drudgery, facilitates early sowing, reduces water requirement, enhances tolerance to water deficit,

advances crop maturity by 7-10 days, reduces cost of cultivation, gives higher yield and more profit, improves soil physical conditions for succeeding crops, thereby increases the productivity and returns (Nageswari and Subramanian, 2004) [12]. Keeping these points in view, an investigation was undertaken to develop appropriate crop management practice to improve the productivity and profitability in rice.

Materials and methods

An experiment was conducted during 2013 and 2014 at Agronomy Main Research Farm, OUAT, Bhubaneswar. During *kharif*, the seven crop management practices in rice viz. E_1-Broadcasting of seeds + *beushaning-khelua* + manual weeding at 35 DAS, E_2-DSRL + mechanical weeding at 21 and 35 DAS, E_3-DSRL + application of pendimethalin 1.0 kg/ha as pre-emergence spray + bispyribac Na at 21 DAS, E_4-DSRL + pendimethalin 1.0 kg/ha as pre-emergence spray + manual weeding at 35 DAS, E_5-DSRL + bispyribac Na 0.02 kg/ha at 21 DAS, E_6-Drum seeding + application of bispyribac Na 0.02 kg/ha at 21 DAS + mechanical weeding at 35 DAS, E_7-Transplanting + application of bispyribac Na 0.02 kg/ha at 21 DAS + mechanical weeding at 35 DAS were tried in randomized block design (RBD) with three replications. Rice cv. Naveen (CR-749-20-2) was taken as test variety of the crops. The soil of the experimental site was sandy loam with acidic pH of 5.4, medium in OC (0.51%), medium in available N (251.3 kg/ha), low in available P (10.3 kg/ha) and available K (111.3 kg/ha).

Result and discussion

Transplanted rice with post emergence application of bispyribac sodium followed by mechanical weeding ranked the first for all growth parameters and yield attributing characters followed by drum seeding with same management practices (Table 1). Complete weed free condition in case of transplanting and drum seeding due to puddling favoured early plant vigor as compared to row seeded rice in which the crop growing environment was partially weed free. Halder *et al*. (2009) [7] and Mohanty *et al.* (2014) [11] reported the same.

Transplanted rice with post emergence application of bispyribac sodium followed by mechanical weeding recorded the maximum grain yield (4.64 t/ha) and straw yield (6.58 t/ha) while farmers practice of broadcasting recorded the minimum yield (Table 2). The higher yield in transplanted rice is due to better weed control by puddling, optimum plant to plant and row to row spacing and adequate plant stand, whereas in broadcasting there was inadequate plant population, uneven plant stand and poor weed control which ultimately resulted in inferior growth parameters, yield attributes and yield (Singh *et al.*,2004) [15]. Puddling in transplanting and drum seeding provided clean weed control during initial period of crop establishment whereas, line sown direct seeded rice with different types of weed management could not provide weed free environment to the crop during early part of crop establishment (Chauhan and Yadav, 2013) [3]. Drum seeding with post-emergence application of bispyribac sodium followed by mechanical weeding ranked the second for yield of grain, but it was statistically at par with transplanting during 2013 and significantly inferior in 2014 due to better weed control. Direct seeded rice in line gave comparatively less grain yield as compared to transplanting and drum seeding. This statement was agreed by Brar and Bhullar (2013) [2] and Khare *et al*. (2014) [9].

In rice**,** transplanting recorded significantly higher gross return (₹67,771/ha) and net return (₹37,104/ha) compared to drum seeding and farmers practice of broadcasting. Sanjay (2006) [13] supported this statement (Table 3). Direct Seeded Rice in Lines with pre-emergence application of pendimethalin followed by hand weeding gave the maximum return per rupee investment (2.42) per ha due to less expenditure, decrease in labour cost and elimination of nursery bed preparation and transplanting of seedling as compared to transplanting and drum seeding, as there was gradual increase in cost of cultivation. This is in conformity with findings of Yadav and Singh (2006) [17] and Singh and Singh (2010) [14].

Table 1: Growth and yield parameters of rice under various crop management practices

Treatments	Plant height (cm) at harvest			LAI at 75 DAS			Grains / panicle			1000 grain weight (g)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
E_1-FP	90.1	107.9	99.1	5.14	5.35	5.25	103	106	105	25.81	26.33	26.07
E_2-DSRL +MW	93.3	117.8	105.6	5.24	5.70	5.47	113	115	114	27.33	27.57	27.45
E_3-DSRL+PrE +PoE	97.6	123.7	110.7	5.31	6.07	5.69	115	118	117	27.52	28.12	27.82
E_4-DSRL+ PrE +HW	97.8	130.6	114.2	5.41	6.13	5.77	119	121	120	28.07	28.63	28.35
E_5-DSRL+ PoE	92.9	113.9	103.4	5.20	5.43	5.32	110	111	111	26.67	26.85	26.76
E_6-Drum seeding+ PoE +MW	102.6	132.8	117.7	5.43	6.47	5.95	122	126	124	28.66	29.11	28.88
E_7-TP+ PoE +MW	119.8	139.7	129.7	5.64	7.05	6.34	129	133	131	29.28	29.87	29.58
SEm±	1.9	0.9	1.5	0.07	0.55	0.21	3.4	3.1	2.1	0.4	0.5	0.1
CD(P=0.05)	5.7	2.8	4.2	0.23	1.70	0.65	10.4	9.5	5.7	1.2	1.5	0.3

DSRL- Direct seeded rice sown in lines, FP- Farmers' practice, PrE-Pre-Emergence, PoE – Post Emergance, HW – Hand Weeding

Table 2: Grain and straw yield of rice under various crop management practices

Treatments	Grain yield (t/ha)			Stover yield (t/ha)		
	2013	2014	Pooled	2013	2014	Pooled
E_1-FP	2.88	3.05	2.97	4.26	4.62	3.66
E_2-DSRL+MW	2.91	3.18	3.04	4.28	4.68	3.73
E_3-DSRL+PrE +PoE	3.26	3.77	3.52	4.59	5.41	4.18
E_4-DSRL+ PrE +HW	3.76	4.09	3.93	5.33	5.78	4.71
E_5-DSRL+ PoE	2.86	3.12	2.99	4.30	4.79	3.71
E_6-Drum seeding+ PoE + HW	3.83	4.18	4.00	5.47	5.82	4.83
E_7-TP+ PoE + HW	4.37	4.91	4.64	6.22	6.58	5.56
SEm±	0.24	0.22	0.15	0.36	0.37	0.23
CD(P=0.05)	0.75	0.66	0.41	1.10	1.13	0.64

DSRL- Direct seeded rice sown in lines, FP- Farmers' practice, PrE-Pre-Emergence, PoE – Post Emergance, HW – Hand Weeding

Table 3: Effect of crop management practices on economics of rice

Treatments	Gross return (₹/ha)			Net return (₹/ha)			Return/rupee investment		
	2013	2014	Pool ed	2013	2014	Pool ed	2013	2014	Pool ed
E_1-FP	41,556	45,644	43,600	13,712	16,212	14,962	1.49	1.55	1.52
E_2-DSRL+MW	41,958	47,447	44,702	18,945	23,792	21,368	1.82	2.01	1.91
E_3-DSRL+PrE +PoE	46,832	56,131	51,482	22,097	31,261	26,679	1.89	2.26	2.08
E_4-DSRL+ PrE +HW	54,051	60,822	57,436	30,560	36,812	33,686	2.30	2.54	2.42
E_5-DSRL+ PoE	41,325	46,737	44,031	17,964	23,241	20,603	1.77	1.99	1.88
E_6-Drum seeding+ PoE +MW	55,088	62,066	58,577	30,575	37,418	33,996	2.25	2.52	2.38
E_7-TP+ PoE +MW	62,838	72,704	67,771	32,856	41,352	37,104	2.09	2.32	2.21
SEm±	3453	3236	2168	3446	3342	2206	0.14	0.14	0.09
CD(P=0.05)	10,639	9969	6009	10,619	10,296	6113	0.44	0.44	0.25

DSRL- Direct seeded rice sown in lines, FP- Farmers' practice, PrE-Pre-Emergence, PoE – Post Emergance, HW – Hand Weeding

Conclusion

Application of pendimethalin 1.0 kg/ha as pre-emergence spray followed by hand weeding at 35 days after sowing in line sown direct seeded rice can be recommended in place of application of bispyribac sodium 0.02 kg/ha with mechanical weeding at 35 DAS in both transplanted and drum seeded rice without appreciable loss in yield and monetary return.

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