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Effect of establishment methods under different weed management technique on rice and associated weeds

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Abstract
An experiment was conducted during rainy (*kharif*) season of 2011 and 2012 to find out the best weed management technique and crop establishment method of rice (*Oryza sativa* L.). Both of the transplanting methods being at par recorded significantly higher values of plant height, leaf-area index and grain yield over direct seeding methods. Among weed management practices, two hand weeding (30&50 days) and Bispyribac-Na 25 g ha^{-1} followed by manual weeding at 50 days at par recorded significantly lower weed weed density & weed dry weight of weeds over Bispyribac-Na 25g ha^{-1} alone and weedy check treatments. Amongst all the interaction, the maximum grain yield was observed in both of transplanting methods being at par significantly with two hand weeding and Bispyribac-Na 25 g ha^{-1} at 30 days stage being at par proved significantly. The highest weed control efficiency (89.67%) was recorded in two hand weeding, followed by herbicide + one hand weeding, the highest net profit (Rs 61,372 ha^{-1}) was obtained from the combination of conventional transplanting with herbicide + one hand weeding. However, the highest value of benefit: cost ratio (2.33) was recorded in the treatment with drum seeding with bispyribac Na 25g ha^{-1} at 30 days.

Keywords: Rice, establishment, transplanting methods, direct seeding, weed managements

Introduction
Rice (*Oryza sativa* L.) is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (~10,000 years), rice is the staple food for 2.5 billion people (1) and growing rice is the largest single use of land for producing food, covering 9% of the earth's arable land. Rice is the principal food for India people, being grown in 44.6 million ha, with a production of 87 million tonnes (Anonymous, 2005). Rice is the most important cereal crops as it is a staple food of more than 70 % of the world population. The method of rice establishment in rice largely affects initial stand uniformity. Although transplanting methods of establishment has been reported to be best amongst all the factors for higher productivity of rice, this method is not much profitable due to higher labour wages and the problem of unavailability of labour during the peak period of operation. Some alternatives such as drum seeding, direct seeding, zero tillage in rows or broadcast of sprouted seeds under puddle condition, must be explored. Weed menance is 50-60% more in direct-seeded rice than in transplanted rice. Manual weeding becomes difficult because of possible damage to rice plants, problem in differentiating grassy weeds, labour scarcity, time consumed and relatively less effectiveness. Chemical control using herbicide controls more weed species. The objective of this experiment was to evaluate the effect of various rice establishment methods on growth and yield of rice and associated weeds and to develop optimum combination of establishment methods and weed management practices.

Material and methods
The field experiment was conducted during two consecutive seasons of *kharif* 2011 and 2012 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). The soil was silty loam. With pH 7.8. the available N.P. and K content in the soil was 187.91, 14.68 and 257.24 kg ha^{-1} respectively. The treatments comprised four rice establishment methods (system of rice intensification, conventional transplanting, drum seeding and direct seeded rice under puddled condition) two types of nurseries were raised for the rice crop. In case of conventional technique, raised beds of 10×1.25 m were prepared with the help of tractor and spade. The seed was sown 10 cm apart in rows, whereas for raising seedling under SRI, four raised beds of 3.0×1.25 m dimension were prepared by spade with a water channel of 0.5 width made round consisting of alternate layers of soil and well decomposed FYM of 1.5" and 1" thickness respectively,

until it was 6" above the ground level having final layer of 2.5"thickness. On these beds pre-germinated seeds at 6 kg ha^{-1} were broadcasted and the beds were mulched for first three days to avoid bird damage. Beds of both the nurseries were irrigated frequently to maintain adequate soil moisture. In case of conventional transplanting, 27-28 days old seedling and 2-3 seedlings/hill were planted in normal spacing of 20×10 cm whereas in case of SRI, 14 days old seedlings were removed carefully along with soil from the nursery bed without damaging the root zone and then single seedling/hill was transplanted 1-2 cm deep into the soil that is muddy but not flooded at a spacing of 25×25 cm on the same day of transplanting. However, for direct seeding treatments (direct seeding, and drum seeding), a seed rate of 80 and 22 kg/ha was used for broad-casting and drum seeding treatments, respectively. Sowing in direct seeding plots was done by broad cast and through drum seeder as per treatment.The seed was soaked in water for 12 hours, and piled and covered with moist gunny bag for 24 hours for sprouting. Puddling in drum seeding plots was done just before sowing of seed by giving two cross ploughing with desi plough followed by planking in ponded water, after that sprouted seeds of rice were sown with drum seeder in row at 20cm a part.and four weed-management practices the (Bispyribac-Na 25g ha^{-1}, Bispyribac-Na 25g ha^{-1}+ one hand weeding, two hand weeding and weedy check). These were tested in split-plot design with three replications. Half the dose of N (60 kg) and full dose of P_2O_5 (60 kg ha^{-1}) and Zn SO_4 (25 kg ha^{-1}) was applied basal before sowing or puddling. The remaining half nitrogen (60 kg ha^{-1}) was top-dressed in two equal splits at tillesring and panicle-initiation stages. Rice 'sarjoo 52' was sown on 27 June 2011 and 29 June2012. For transplanting, the crop was sown in the nursery on the same dates. Different weed-management techniques for rice establishment methods. The observation on the population count and dry weight of weeds were recorded. Weed data were transformed $\left(r = \sqrt{X + 0.5}\right)$ before statistical analysis. The yield parameter and yields were recorded and economics was worked out.

Result and discussion

Effect on growth and yield attributes

Establishment method and weed management techniques had significant effect on growth and yield attributes, viz. Plant height, dry weight/m^{-2}, leaf area index/hill, effective shoot/hill, grains/panicle, panicle length/cm and test weight, during both the years (Table 1). System of rice intensification (SRI) and conventional method being at par with regard to plant height, leaf area index effective, shoot, grain, panicle, length and Test weight of establishment methods recorded significantly higher over DSR methods this might be due to this better weed control in transplanting over DSR methods. Likewise, both of the DSR methods also recorded plant height growth and yield attributes at par to each other Kumar *et al.* (2007) also reported the similar results. Both of the transplanting methods being at par recorded significantly more yield attributes over direct and drum seeding methods. However, drum seeding method of rice establishment recorded significantly higher yield attributes over broad-cast seeding method. Likewise, SRI method recorded numerically higher values of effective shoots (m^{-2}) during both the years. The highest values of these attributes was recorded under transplanting methods over direct seeding treatments especially for effective shoots m^{-2}, length of panicles (cm), number of grain per panicle and 1000grain weight.

As far as the various weed management practices were concerned, growth and yield attributes was influenced significantly at all the stage of crop growth due to various weed management practices. Manual weeding twice (30 & 50 days) and bispyribac-Na 25g ha^{-1} at 30 DAS PoE fb manual weeding at 50 days stage of planting / seeding being at par recorded significantly more growth and attributes over bispyribac-Na alone and weedy check treatments. However, weedy check treatment recorded significantly lower growth and attributes over rest of the weed control treatments at all the stages of crop growth during both the years. Similar findings have also been reported by Saha (2006) and Shivaramu and Krishnamurthy (2011).

However, for resource poor farmers, direct seeding of rice through drum along with bispyribac Na 25g ha^{-1} at 30 days fb one hand weeding at 50 days stage proved superior (BCR values of 2.23 and 2.33/- per ha). Over other methods of rice establishment under puddled condition. Both of the transplanting methods being at par recorded significantly more number of effective shoots (m^{-2}) over direct and drum seeding methods. However, drum seeding method of rice establishment recorded significantly higher number of effective shoots (m^{-2}) over broad-cast seeding method. Likewise, SRI method recorded numerically higher values of effective shoots (m^{-2}) during both the years. As far as the various weed management practices were concerned, hand weeding twice (30 & 50 DAS/T) being at par with bispyribac-Na 25g ha^{-1} at 30 DAS/T fb hand weeding at 50 days stage recorded significantly higher number of effective shoots (m^{-2}) as compared to bispyribac-Na 25g ha^{-1} at 30 days stage alone and weedy check. However, bispyribac-Na 25g ha^{-1} recorded significantly higher number of effective shoots over weedy check. Weedy check produced significantly less number of effective shoots as compared to all the weed management practices during both the years experimentation.

Table 1: Growth, yield attributes and yields of rice as affected by establishment method and weed-management technique

Treatment	Plant height (cm)		Leaf area index /hill		Grain/panicle		Length of panicle/cm		Effective shoot/m		Grain yield (q/ha)		Straw yield (q/ha)		Test weight (g)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Methods of rice establishment																
SRI	88.26	88.66	3.13	3.23	114.72	118.74	25.05	26.12	371.34	375.62	52.92	54.77	65.25	67.62	23.26	24.18
CT	82.42	85.14	3.05	3.20	112.81	114.86	23.23	25.48	350.53	352.36	51.45	53.43	64.24	66.17	22.71	23.92
DSR	68.92	70.16	2.69	2.76	92.36	93.48	19.02	19.16	266.64	272.45	35.32	38.78	48.78	46.01	21.74	22.12
Drum	75.06	77.48	2.90	2.95	102.43	104.37	21.13	23.37	310.26	315.28	45.14	46.68	55.90	57.84	22.25	23.00
CD(P=0.05)	6.73	7.80	0.13	0.30	8.94	9.27	1.89	1.98	24.21	28.41	4.23	4.63	5.67	5.59	NS	NS
Weed management techniques																
Bis.	76.05	80.21	3.01	3.12	105.38	106.56	21.50	22.46	320.95	325.16	45.65	47.68	59.02	58.96	22.50	23.73
Bis+Hw 50	87.69	88.72	3.15	3.25	112.63	115.16	23.76	25.68	355.80	360.32	55.54	56.78	68.99	69.82	22.74	23.85
Two Hw	84.93	86.23	3.13	3.27	113.89	117.68	24.95	25.84	370.14	376.10	56.26	57.57	70.52	70.27	23.45	24.26
Weedy check	65.99	66.28	2.48	2.50	90.42	92.05	18.22	20.15	251.88	252.13	27.37	31.62	35.64	38.35	21.27	21.38
CD (P=0.05)	4.89	4.96	0.16	0.17	6.79	6.39	1.44	1.51	16.80	17.95	2.79	2.77	3.27	3.58	1.33	1.38

SRI- system of rice intensification, CT- conventional transplanting, DSR- direct seeded-rice, Bis.- Bispyribac-Na 25 g ha^{-1}, Hw- hand weeding

Table 2: Dry weight of weeds, weed density and weed control efficiency and as influenced by rice-establishment methods and weed control.

Treatment	Dry weight weeds at 90 DAS (g/m^{-2})		Weed control efficiency (%)		Grassy weeds at 90 DAS/0.5 m^{-2}		Broad-leaved weeds at 90 DAS/0.5 m^{-2}		Sedges weeds at 90 DAS/0.5 m^{-2}		Other weeds at 90 DAS/0.5 m^{-2}	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Rice establishment method												
SRI	(36.75) 5.73	(26.28) 4.76	41.03	34.25	(7.24) 2.78	(4.80) 2.30	(5.88) 2.92	(3.79) 2.44	(2.46) 2.06	(1.44) 1.70	(0.97) 1.21	(0.21) 0.84
CT	(38.45) 5.86	(28.36) 4.94	42.21	35.94	(8.98) 3.08	(5.68) 2.49	(7.12) 3.16	(5.02) 2.74	(3.66) 2.41	(2.01) 1.91	(1.04) 1.24	(0.30) 0.89
DSR	(86.26) 8.54	(80.31) 8.43	66.55	68.84	(22.20) 5.21	(15.77) 4.47	(11.75) 3.92	(5.14) 2.76	(9.22) 3.53	(6.32) 3.01	(2.98) 1.87	(2.25) 1.66
Drum	(60.46) 7.27	(50.43) 6.50	55.02	50.65	(17.08) 4.63	(10.44) 3.73	(6.38) 3.02	(3.12) 2.26	(4.17) 2.54	(4.06) 1.97	(1.82) 1.52	(0.97) 1.21
(P=0.05)	0.55	0.51			0.36	0.33	0.28	0.32	0.39	0.30	0.22	0.13
Weed management techniques											0.55	0.51
Bis.	(40.71) 6.33	(34.57) 5.75	46.48	43.58	(8.80) 3.05	(7.88) 2.89	(10.31) 3.22	(7.47) 2.75	(7.22) 2.66	(6.27) 2.44	(3.02) 1.88	(1.91) 1.55
Bis+Hw 50	(25.50) 5.02	(19.10) 4.29	34.58	29.82	(5.91) 2.53	(4.46) 2.23	(5.63) 2.42	(1.09) 1.24	(3.02) 1.81	(2.32) 1.60	(1.26) 1.33	(0.63) 1.06
Two Hw	(24.32) 4.91	(17.21) 4.09	33.58	27.93	(4.86) 2.32	(3.13) 1.91	(3.51) 1.97	(0.95) 1.19	(1.85) 1.49	(1.68) 1.42	(1.14) 1.28	(0.44) 0.97
Weedy check	(125.44) 11.01	(120.45) 10.61			(32.50) 5.74	(27.30) 5.27	(23.14) 4.73	(22.10) 4.59	(15.12) 3.76	(10.78) 3.12	(5.74) 2.50	(4.16) 2.16
CD (P=0.05)	0.40	0.38			0.26	0.25	0.25	0.16	0.29	0.21	0.12	0.10

DAS- date after sowing, original values are given is parentheses

Table 3: Economics and Spectrum of weed flora in weedy check plot as influenced by rice-establishment methods and weed control

Treatments	Economics of different treatments						Weed species	Spectrum of weed flora	
	Cost of cultivation (Rs ha^{-1})		Net return (Rs ha^{-1})		B-C ratio (Rs re^{-1} Invested)			At 60 DAS	
	2011	2012	2011	2012	2011	2012		2011	2012
M_1W_1	29653.00	30019.00	45060.00	49262.00	1.51	1.64	*E. crusgalli*	19.40 (16.45)	17.69 (16.24)
M_1W_2	33153.00	33519.00	57154.00	59838.00	1.72	1.78	*E. colona*	27.46 (23.28)	20.16 (18.52)
M_1W_3	34878.00	35244.00	56684.00	58812.00	1.62	1.66	*P. maximum*	23.10 (19.58)	19.74 (18.12)
M_1W_4	27878.00	28244.00	15770.00	20270.00	0.56	0.71	*C. benghalensis*	9.21 (7.80)	13.97 (12.84)
M_2W_1	25935.00	26585.00	47726.00	50948.00	1.84	1.91	*Eclipta alba*	20.03 (16.98)	22.39 (20.55)
M_2W_2	29435.00	30085.00	58385.00	61372.00	1.98	2.03	*C. speices*	14.05 (11.91)	11.19 (10.27)
M_2W_3	31160.00	31810.00	58339.00	60425.00	1.87	1.89	*Other weeds*	4.68 (3.98)	3.79 (3.47)
M_2W_4	24160.00	24810.00	17653.00	21655.00	0.73	0.87	Total weeds	117.93 (100.0)	108.93 (100.0)
M_3W_1	21055.00	21445.00	24653.00	27970.00	1.17	1.30			
M_3W_2	24555.00	24945.00	38325.00	39454.00	1.56	1.58			
M_3W_3	26280.00	26670.00	37245.00	39257.00	1.41	1.47			
M_3W_4	19280.00	19670.00	20588.00	21902.00	1.06	1.11			
M_4W_1	20121.00	20453.00	44993.00	47828.00	2.23	2.33			
M_4W_2	23621.00	23953.00	50994.00	53328.00	2.15	2.22			
M_4W_3	25346.00	25678.00	50398.00	52604.00	1.98	2.04			
M_4W_4	18346.00	18678.00	22517.00	26322.00	1.22	1.40			

Effect on yield

The system of rice intensification (SRI) being at par with conventional transplanting (CT) produced significantly higher grain and straw yields over all other establishment methods during both the years. Transplanting of rice through SRI technique and conventional method being at par recorded significantly higher values of grain and straw yield over direct seeding (broad-casting and drum seeding methods). Singh *et al.* (2013) reported from IARI, New Delhi that conventional and SRI establishment methods gave statistically at par grain yield but straw yield was significantly higher in CT as compared to SRI. In case of direct seeding of rice treatments, drum seeding treatment recorded significantly higher values of grain and straw yield as compared to broad-casting of rice (DSR) treatments during both the years of experimentation (Table 1) As far as the various weed management practices were concerned, hand weeding twice (30 & 50 DAS/T) being at par with bispyribac-Na 25g ha^{-1} at 30 DAS/T fb hand weeding at 50 days stage recorded significantly higher values of grain and straw yield as compared to bispyribac-Na 25g ha^{-1} at 30 days stage alone and weedy check. However, bispyribac-Na 25g ha^{-1} alone recorded significantly higher values of grain and straw yield over weedy check. Weedy check produced significantly lower grain and straw yield as compared to all the weed management practices during both the years of experimentation. Such type of results with respect to grain and straw yield were recorded on the lines of growth and yield attributes recorded with the respective treatment. These finding are well supported by Yadav and Singh (2009) [7] They reported that weed-management practices, anilofos + two hand weddings gave the highest grain yield (60.96q/ha), and transplanting and anilofos + two hand weeding gave the highest straw yield.

Interaction effect

The interaction effect of establishment methods and weed-management technique on grain yield was found significant during both the years. All the interaction, the maximum grain yield was observed in both of transplanting methods being at par significantly with two hand weeding and Bispyribac-Na

25 g ha^{-1} at 30 days stage being at par proved significantly. Higher grain yield of 64.41q/ha during 2011 was recorded in combination of SRI with Two Hand weeding, whereas during 2012 the highest grain yield of 65.28 q/ha was recorded numerically values in the combination of transplanting with two hand-weedings.

Weed Florai

The experimental site was infested with both grassy, broad and sedges leaved weeds *Echinochloa colona* was recorded higher as compared to *E.crusgalli* and *Panicum maxicum*. In case of BLWs, *Eclipta alba* density recorded higher (as % contribution in total weeds) as compared to *Commelina benghalensis* at all the stages of crop growth, Among the sedges, *Cyperus rotundus*, *Cyperus difformis*, *Cyperus esculentus* as well as *Fimbristylis dentatum* were recorded, but *Cyperus rotundus* proved dominant species during both the years. However, few plants of *Eleusine indica*, *Ludwigia parviflora* and *Caesulia axillaries* were also recorded and grouped as other weeds (Table 3).

Effect on economics

maximum cost of cultivation (Rs. 34878.00 ha^{-1} and Rs. 35244.00 ha^{-1}) was incurred under SRI with two hand weeding (30&50 days stage) treatment followed by Rs. 33153.00 ha^{-1} and Rs. 33519.00 ha^{-1} under SRI with bispyribac-Na fb one hand weeding (M_1 W_2) during 2011 & 2012, respectively. As far as the other establishment methods along with weed control practices were concerned, lower values of cost of cultivation (Rs. 18346.00 ha^{-1} and Rs. 18678.00 ha^{-1}) was incurred in drum seeding with weedy check treatment.

The maximum net return of Rs. 58385.00 ha^{-1} and Rs. 61372.00 ha^{-1} (2011 & 2012) was obtained under conventional transplanting compled with bispyribac-Na fb one hand weeding treatment followed by conventional transplanting compled with two hand weeding 30 & 50 days stage Rs. 58339.00 ha^{-1} and Rs. 60425.00 ha^{-1}. Likewise, lower values of net return of Rs. 15770.00 ha^{-1} and Rs. 20270.00 ha^{-1} were recorded due to a combination of system of rice intensification compled with weedy check treatment during 2011 & 2012.

Revealed that over all maximum benefit-cost ratio of drum seeding method Rs. 2.23 and Rs. 2.33 was obtained under drum seeded rice along with bispyribac-Na followed by Rs. 2.15 and Rs. 2.22 under drum seeded rice with bispyribac-Na fb one hand weeding during both the years.

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