Society for Advancement of Wheat and Barley Research
ICAR-Indian Institute of Wheat & Barley Research
Karnal - 132 001, India

Journal of Cereal Research
11(3): 300-303
Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Short Communication

Effect of various crop establishment methods and herbicides on growth and yield of rice

Dhiman Mukherjee*

Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal - 741235

Article history: Received: 14 Oct., 2019 Revised: 21 Nov., 2019 Accepted: 24 Dec., 2019

Citation: Mukherjee D. 2019. Effect of various crop establishment methods and weed management practices on growth and yield of rice. *Journal of Cereal Research* **11**(3): 300-303. http://doi.org/10.25174/2249-4065/2019/95811

Corresponding author: *E-mail: dhiman_mukherjee@yahoo.co.in*

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Keywords: Bispyribac, direct seeded rice, oxadiargyl pyrazosulfuron, transplanted rice, zero tillage

Emphasis on the climate resilience cropping system under Indian agriculture system is vital to the livelihood security of many small and marginal farmers in the country, mainly who depend as rice their staple food. Devising suitable adaptation strategies will facilitate farmers to handle with various climate risks and promote efficient use of limited available resources to bring sustainability to farm production and stability to their incomes. Rice *(Oryza sativa* L.), covered about 42 m ha and accounts for about 103.61 million tonnes of the country's total food grain production and globally is a popular crop (Tomar *et al.*, 2018). Under Indo-Gangetic Plains (IGP), transplant of rice crop requires high amount of water for puddling process to avert seepage losses. However, the wet tillage destroys the soil structure and also huge labour force is required for transplanting. Direct seeded rice (DSR) is an alternative to transplanted rice. This technique evade the main crisis faced in West Bengal i.e., manpower scarcity for transplanting due to peak demand. Moreover, under shortage of irrigation water and delayed monsoon, DSR is better option. This helps timely sowing of the following mustard, wheat or other rabi crops (Mukherjee, 2016). Jat *et al.* (2014) found that 7-10% reduction in wheat yield when sown after transplanted rice compared with when sown after DSR in non-puddled conditions. However, with the change in paddy cultivation practices, weed invasion and crop-weed competition are predicted to increase and will remain to be a primary challenge s for enhancing and maintaining high yield potential (Mukherjee and Mandal, 2017). Yield loss of rice observed to the extent of 40 to 65% due to weed competition (Yakadri *et al.*, 2016). Keeping this aspect in mind present investigation was conducted, with the objective to optimize rice yield under different crop establishment method with various chemical control options.

Present study was conducted at Bidhan Chandra Krishi Viswavidyalaya during *kharif* seasons of 2017 and 2018. Experiment was laid out in split plot design with three replications. Four crop establishment methods *viz.*, CE 1: Conventional till rice (puddled transplanted) (CTPTR), CE 2: Zero-till direct seeded rice (ZTDSR), CE 3: Conventional till direct seeded rice (CTDSR), CE 4: Broadcasting of rice seedlings were in main plots. Six weed management practices consisted of oxadiargyl at 100 g ha^{-1} at 3 DAS / DAT, pyrazosulfuron ethyl at 25 g ha^{-1} at 3 DAS / DAT, oxadiargyl 100 g ha^{-1} *fb* bispyribac-Na 25 g ha^{-1} at 25 DAS / DAT, pyrazosulfuron ethyl at 25 g ha^{-1} at 3 DAS / DAT *fb* bispyribac Na at 25 g ha^{-1} at 25 DAS / DAT, weed free and weedy check treatments were in sub-plots during both the years. Herbicides were applied with 500 litre ha^{-1} of water using knapsack sprayer, fitted with flat-fan nozzle. In CTDSR and ZTDSR treatments, sowing was done by using tractor drawn zero-till seed-cum-fertilizer planter with a row spacing of 20 cm and seeding depth was maintained at 2–3 cm using depth control wheel of the planter. Rice variety '*Shatabdi'* was used at the rate of 30 Kg ha^{-1}. Seeding was done on 23rd June during 2017 and 28th June during 2018 in CTDSR and ZTDSR plots. On the same day seeds were sown in nursery for CTPTR and for broadcasting seedling. Twenty five days old seedlings were manually transplanted in line (2-3 seedlings $hill^{-1}$) with a spacing of 20 cm × 20 cm. The recommended dose of nutrients was 80:40:40:25 Kg ha^{-1} of N: P_2O_5: K_2O: Zn. Entire quantity of all fertilizers except urea was applied as basal dose during final land preparation and mixed thoroughly with soil. Urea was applied in three equal instalments *i.e.,* during sowing/transplanting, tillering stage and seven days before panicle initiation. Harvesting was done from 25th October to 7th November, depending upon the maturity of the planting methods. Yield of both grain and straw was expressed in Kg ha^{-1}. Weed population and weed dry weight were recorded at 60 and 90 DAS / DAT by placing a quadrate of 50 cm x 50 cm randomly at two spots in each plot. Data on weed count and weed dry weight were subjected to square root transformation before statistical analysis. Analysis of variance (ANOVA) of two years pooled data was done using the CoStat Software. The differences between treatment means were compared using a LSD test at $P < 0.05$ (Gomez and Gomez, 1984).

Amongst various treatments, highest plant height at 60 and 90 DAS / DAT was observed with conventional till rice (CE 1), and significantly better to rest of the crop establishment treatments. Various weed control practices revealed that, more plant height observed with the weed free situation at 60 DAS / DAT and were at par with the pyrazosulfuron ethyl at 25 g ha^{-1} at 3 DAS / DAT and pyrazosulfuron ethyl at 25 g ha^{-1} at 3 DAS / DAT *fb* bispyribac Na 25 g ha^{-1} at 25 DAS / DAT. However, at 90 DAS / DAT significantly more height observed with oxadiargyl 100 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} at 25 DAS / DAT and was superior to other treatments. Statistically no difference was observed in case of LAI. At 60 DAS / DAT, however more value observed with zero-till direct seeded rice (ZTDSR). At 90 DAS / DAT, significantly higher LAI was registered with the CTPTR compared to other treatments. Amongst various weed control measures, highest LAI, was recorded with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} at 25 DAS / DAT and was at par with the all the treatments except weedy situation at 60 and 90 DAS / DAT, and pyrazosulfuron ethyl at 25 g ha^{-1}only at 90 DAS / DAT of data recoding. Chlorophyll content was at par with all the treatments except broadcasting of seedlings (CE 4) at 60 DAS / DAT. However, at 90 DAS / DAT, this treatment was statistically better to other set of crop establishment measures. With various sub plot treatments, highest chlorophyll content was found with the pyrazosulfuron ethyl at 25 g ha^{-1}at 3 DAS *fb* bispyribac Na 25 g ha^{-1}at 25 DAS / DAT and was at par with oxadiargyl at 100 g ha^{-1} at 3 DAS / DAT. Further, at 90 DAS / DAT higher values were observed with the weed free situation and was at par with the oxadiargyl 100 g ha^{-1}*fb* bispyribac-Na 25 g ha^{-1}, and significantly better to other treatments. During both the stage of data recording, significantly higher number of tillers per hill were observed with the conventional till rice (puddled transplanted) and showed parity with conventional till direct seeded rice. Weed control options revealed that, tiller counting was more observed with the weed free situation at 60 DAS / DAT and was significantly better to other treatments

Table 1: Effect of crop establishment methods and weed control measures on various growth parameters of rice.

Treatments	Plant height (cm)		Leaf area index		Chlorophyll content (SPAD unit)		No. of tillers $hill^{-1}$		Shoot dry matter (g $hill^{-1}$)	
	60 DAS / DAT	90 DAS / DAT	60 DAS / DAT	90 DAS / DAT	60 DAS / DAT	90 DAS / DAT	60 DAS / DAT	90 DAS / DAT	60 DAS / DAT	90 DAS / DAT
Crop establishment methods (CE)										
CE 1: Conventional till transplanted rice	83.7	110.7	4.36	7.92	32.22	27.43	11.1	18.1	15.16	31.40
CE 2: Zero-till direct seeded rice	62.4	95.8	4.82	5.58	32.11	23.77	9.1	16.4	12.33	30.35
CE 3: Conventional till direct seeded rice	71.8	100.8	4.47	7.05	32.47	30.12	10.8	17.5	14.54	29.77
CE 4: Broadcasting seedlings	80.8	91.1	4.27	6.76	28.69	22.43	8.8	15.1	11.04	27.87
SEm ±	1.24	1.33	0.39	0.27	0.46	0.67	0.15	0.16	0.60	1.04
LSD(P=0.05)	3.45	3.90	NS	0.61	1.13	1.85	0.44	0.42	1.71	3.09
Weed management practices										
Oxadiargyl @ 100 g ha^{-1} at 3 DAS / DAT	73.5	96.9	4.73	7.23	34.33	24.40	9.9	15.6	12.07	27.21
Pyrazosulfuron ethyl @ 25 g ha^{-1} at 3 DAS	76.0	101.6	4.19	6.21	25.11	23.25	9.0	16.2	14.11	28.60
Oxadiargyl 100 g ha^{-1} *fb* bispyribac Na @ 25 g ha^{-1} at 25 DAS / DAT	73.0	109.4	4.80	7.11	33.63	29.13	10.6	17.8	14.14	31.87
Pyrazosulfuron ethyl @ 25 g ha^{-1} at 3 DAS / DAT *fb* bispyribac Na @ 25 g ha^{-1} at 25 DAS / DAT	76.4	96.7	5.00	7.83	34.60	24.77	10.2	19.9	10.11	30.25
Weed free	78.0	100.8	4.50	7.12	33.66	30.36	11.3	17.4	18.29	34.96
Weedy	71.2	91.9	3.77	5.42	27.11	22.52	7.65	13.4	10.25	26.17
SEm ±	1.04	1.25	0.36	0.22	0.33	0.67	0.14	0.19	0.57	1.17
LSD(P=0.05)	3.11	3.91	0.94	0.61	0.88	1.77	0.40	0.57	1.62	3.33

NS = Non significant

Table 2: Effect of treatments on weed density, weed dry weight, yield and yield attributes component and economics of rice.

Treatments	Total weed density (no. m^{-2})	Total weed dry matter production (g m^{-2})		Effective tillers (No. m^{-2})	1000 grains weight (g)	Grain yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Cost of production (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit: Cost ratio
	60 DAS / DAT	60 DAS / DAT	90 DAS / DAT							
Crop establishment methods (CE)										
CE 1: Conventional till transplanted rice	8.84(77.7)*	5.64(31.4)	5.39(28.5)	300.1	23.5	49.41	68.79	46948	35563	1.76
CE 2: Zero-till direct seeded rice	10.07(101.0)	6.27(38.9)	6.03(35.9)	303.1	23.7	38.79	55.48	42238	35763	1.85
CE 3: Conventional till direct seeded rice	10.57(111.3)	6.69(44.3)	6.39(40.4)	353.3	24.3	47.11	70.99	43513	43925	2.01
CE 4: Broadcasting seedlings	11.08(122.3)	6.86(46.7)	6.49(41.6)	231.1	22.1	34.39	58.52	39075	28065	1.72
SEm ±	0.16	0.23	0.22	5.92	0.26	1.11	3.21	1254	1318	0.07
LSD(P=0.05)	0.49	0.66	0.64	15.64	0.55	3.03	9.19	3354	3845	0.19
Weed management practices										
Oxadiargyl @ 100 g ha^{-1} at 3 DAS / DAT	10.78(115.7)	6.12 (37.0)	5.55(30.3)	291.1	21.6	37.60	59.77	38063	32563	1.86
Pyrazosulfuron ethyl @ 25 g ha^{-1} at 3 DAS	11.26(126.3)	6.66(43.9)	6.23(38.3)	268.3	22.1	36.11	54.65	38840	30062	1.77
Oxadiargyl 100 g ha^{-1} *fb* bispyribac Na @ 25 g ha^{-1} at 25 DAS / DAT	7.82(60.7)	4.61(20.8)	4.52(20.0)	324.3	23.4	49.29	67.13	42163	52782	2.25
Pyrazosulfuron ethyl @ 25 g ha^{-1} at 3 DAS / DAT *fb* bispyribac Na @ 25 g ha^{-1} at 25 DAS / DAT	8.37(69.7)	5.11(25.7)	4.87(23.2)	336.3	25.6	48.85	69.53	45988	43055	1.94
Weed free	0.71(0.0)	0.71 (0.0)	0.71(0.0)	342.7	26.8	51.58	77.14	51594	56026	2.09
Weedy check	15.68(245.3)	10.79(115.9)	10.4(108.3)	217.3	21.0	31.11	52.42	31658	25145	1.79
SEm ±	0.18	0.20	0.24	6.19	0.27	1.18	4.02	1324	1404	0.09
LSD(P=0.05)	0.52	0.58	0.71	17.37	0.63	3.41	11.32	3712	3954	0.25

*Figures in parentheses are original values and were analyzed after square root transformation $\sqrt{(x + 0.5)}$

(Table 1). Moreover, at 90 DAS / DAT more number of tillers observed with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1}, and was at par with the oxadiargyl 100 g ha^{-1}*fb* bispyribac-Na at 25 g ha^{-1} and weed free situation. Under various planting measures, shoot dry weight was significantly more with the CE 1 and CE 3 during both the stages, and notably better to rest of the treatments. Various weed control options revealed that, more shoot dry weight observed with the weed free treatments and were at par with oxadiargyl 100 g ha^{-1}a *fb* bispyribac-Na at 25 g ha^{-1} only at 90 DAS / DAT of data recording. Weed population and its total dry weight varied significantly with different treatments (Table 2). Observations revealed that, least total weed density recorded with the conventional till rice and was statistical better to all other main plot treatments at 60 and 90 DAS / DAT. Weed management practices revealed that, lower weed population was found with the oxadiargyl 100 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1}, and was significantly better to all other weed management options except weed free situation. Total weed dry matter was minimum with the conventional till rice during both the stage of data recording, moreover at 60 DAS / DAT, this showed parity only with ZTDSR and notably better to all other main plot treatments. More total weed dry matter production observed with the broadcasting of seedlings during both the stages. Further, with various subplot treatments, lower value of total weed dry matter production observed with the oxadiargyl 100 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1}at 60 and 90 DAS / DAT, and showed parity only with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} at 60 DAS / DAT of data recording.

Effective tillers were more with conventional till direct seeded rice (CE 3) and this treatment was significantly better to other crop establishment measures. Broadcasting of seedlings recorded the lowest effective tillers per unit area. This finding is close conformity with those obtained by Raj *et al.* (2013). Among various sub-plot treatments, better effective tillers were observed with the weed free situation and was at par with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1}. and significantly better to other treatments. Further Table 2 revealed that, filled grain per panicle was more with the CE 2 and was statistically better to all other crop establishment measures. More filled grains per panicle were found with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1}, and was at par with the weed free and oxadiargyl 100 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1}, and significantly better to other treatments. Test weight gave better response with CE 3 and significantly better to all other option under crop establishment. Weed control option revealed that, weed free situation registered more test weight and significantly better to all other control measures. This might be due to lesser weed- crop competition for light, nutrient etc. Significantly higher grain yield observed with the CE 1 (4941 Kg ha^{-1}) and was at par with the CE 3 (4711 Kg ha^{-1}) and statistically better to all other main plot treatments (Table 2). Conventional till rice (puddled transplanted) (CE 1) registered 43.6 and 27.37% more grain yield over the broadcasting seedling and ZTDSR. Further, Table 2 revealed that, compared to best treatment of weed free check (5158 Kg ha^{-1}), the percent reduction in grain yield was the least (8.41%) with oxadiargyl 100 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} (4929 Kg ha^{-1}) followed by application of the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1} (4885 Kg ha^{-1}). They were at par to each other and significantly better to all other weed control measures. This might be because of the effective weed control which resulted to higher values of yield attributes and yield. The results are in agreement with the findings of Yakadri *et al.* (2016). Straw yield was more observed with conventional till direct seeded rice (CE 3) followed by conventional till rice (puddled transplanted) (CE 1). Both the treatments were at par with each other and significantly superior to rest other method of crop establishment mainly because of higher number of tiller m^{-2} with moderate plant height and better performance of yield attributing ultimately led the increased biomass in the CE 3 followed by CE 1. Among various subplot treatments, more straw yield registered with the weed free (7714 Kg ha^{-1}), and showed parity with the pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1} (6953 Kg ha^{-1}) and oxadiargyl 100 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} (6730 Kg ha^{-1}) and significantly better to all other treatments. Interaction effects were found to be non-significant between crop establishment methods and weed control practices. Economics revealed that, more net return (Rs. 43925 ha^{-1}) and B:C ratio (2.1) observed with the conventional till direct seeded rice and showed parity with the zero-till direct seeded rice for B:C ratio (1.85), and significantly better to other main plot treatments. However, under weed control measures more net returns were found with the weed free situation (Rs. 56026 ha^{-1}) and statistically superior to all other treatments. This was followed by oxadiargyl 100 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1} (Rs. 52782 ha^{-1}) and pyrazosulfuron ethyl at 25 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1} (Rs. 43055 ha^{-1}). Moreover, higher B:C ratio was found with the oxadiargyl 100 g ha^{-1} *fb* bispyribac Na at 25 g ha^{-1} (2.25) and showed parity only with the weed free (2.09) treatment, and statistically superior to all other weed management practices. This is mainly due to higher grain and straw yield.

From the above findings, it may be concluded that, conventional till direct seeded rice recorded significantly higher rice yield with more B:C ratio followed by zero-till direct seeded. Direct seeded rice can be an alternative to puddled transplanted rice. Application of pre-emergence oxadiargyl 100 g ha^{-1} *fb* bispyribac Na 25 g ha^{-1} at 25 DAS / DAT is very effective for better weed control and economic returns.

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