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Yield attributes, yield and economics of direct seeded rice as influenced by integrated weed management practices under medium land condition

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Abstract
A field experiment was conducted during the kharif seasons of 2018 at Agronomical Research Farm of Birsa Agricultural University, Ranchi, Jharkhand, to find out the outcomes of yield attributes, yield and economics of direct seeded rice (*Oryza sativa* L.) through applied the various integrated weed management practices. Taking all things together, there were twelve treatment combinations comprising of herbicide application and hand weeding practices. The experiment was laid out in randomized block design and replicated thrice. Results revealed that application of Pretilachlor (30% EC) @ 1.00 kg a.i./ha as PE *fb* Bispyribac sodium (10% SC) @ 0.025 kg a.i. /ha PoE registered higher growth parameter yield attributes *viz*. number of effective tillers (278/m^2), number of filled grains/panicle (120/panicle), 1000 grain weight (23.62 g), grain yield (40.52 q/ha) straw yield (60.09 q/ha) and net return (₹61864/ha) and was similar to 3 hand weeding at 25, 40 and 55 DAS. Hence, on the basis of one year experiment it may be concluded that application of Pretilachlor (50% EC) @ 1.00 kg a.i. /ha as pre-emergence *fb* Bispyribac sodium (10% SC) @ 0.025 kg a.i. /ha post-emergence with weed management cost of Rs 4648 /ha is effective in suppressing weed for higher crop growth, grain yield and net return of direct seeded rice under medium land condition of Jharkhand.

Keywords: Direct seeded rice, herbicides, hand weeding

Introduction
Rice (*Oryza sativa* L.) is the most consumed and extensively grown cereal grain in the world as it is staple food crop for more than half of world population. Rice is the second most widely consumed cereal stand next to wheat and currently has occupied an area of 161.1 million hectares, with a total production of 751.9 million tones with average productivity of 4.67 tons/ha. In India, transplanting seedlings into puddled soil is the traditional system of rice cultivation. Such production system is labour and energy intensive and require large amount of water for puddling and transplanting (Chauhan, 2012a; Chauhan *et al*., 2012b) [1, 2] and is becoming less profitable as these resources are becoming insufficient. With the advent of resource conserving technologies, direct seeding is being emerged as a viable alternative to transplanted rice (Tripathi *et al*., 2004) [6]. Farmers are keen to adopt direct seeded rice (DSR) instead of transplanted rice as there is acute shortage of labour and high wages of labourers in Jharkhand at the peak transplanting time. Direct seeding of rice aides in quick establishment and early harvest than transplanted rice and consequently facilitates timely wheat seeding (Singh *et al*., 2007) [8] thus enhances sustainability of both rice and wheat in rice-wheat cropping system (Singh *et al*., 2005) [9]. DSR has several advantages over puddle transplanting rice.

Weeds are the main biological constraint of direct seeded rice (Chauhan, 2012b) [2]. Success of DSR is mainly depends on effective weed control with all the possible means. The yield loss in DSR is as high as 50-60% due to simultaneous germination of both crop and weeds seeds (Pinjari *et al*., 2016) [10]. Severe infestation of weeds in direct seeded rice is the main problem which causes grain yield loss up to 90% (Gaire *et al*., 2013) [4]. Weed management must aim at reducing the weed population to a level at which occurrence of weeds has no effect on farmer's economic and ecological interests. By using different appropriate management practices against weeds, farmers have more options for controlling weeds, thereby reducing the possibility of escapes and weed adaptation to any single weed management tactic.

Materials and Methods

A field experiment was conducted at agronomical research farm of Birsa Agricultural University, Ranchi, Jharkhand with objective to find out the efficacy of integrated weed management practices for controlling weeds in direct seeded rice under medium land situation. The experimental field was sandy loam in texture, poor in organic carbon (0.38%), available nitrogen (228.12 kg/ha) and medium in available phosphorus (18.92 kg/ha) and potash (154.30 kg/ha). The experiment consisted of altogether 12 treatments *viz*. Pendimethalin (30 EC) @ 0.75 kg a.i. /ha PE (T1), Pendimethalin (30% EC) @ 0.75 kg a.i./ha as PE *fb* 1 hand weeding at 25 DAS (T2), Pendimethalin (30% EC) @ 0.75 kg a.i./ha as PE *fb* 2 hand weeding at 25 DAS and 40 DAS (T3), Pendimethalin (30% EC) @ 0.75 kg a.i. /ha PE *fb* Sesbania incorporation at 25 DAS (T4), Pendimethalin (30% EC) @0.75 kg a.i. /ha as PE *fb* Bispyribac Sodium (10% SC) @ 0.025 kg a.i. /ha PoE (T5), Pretilachlor (50% EC) @1.00 kg a.i. /ha PE (T6), Pretilachlor (50% EC) @ 1.00 kg a.i. /ha PE *fb* 1 hand weeding 25 DAS (T7), Pretilachlor (50% EC) @1.00 kg a.i. /ha PE *fb* 2 hand weeding at 25DAS and 40 DAS (T8), Pretilachlor (50% EC) @ 1.00 kg a.i. /ha *fb* Sesbania incorporation at 25 DAS (T9), Pretilachlor (50% EC) @ 1.00 kg a.i. /ha PE *fb* Bispyribac Sodium (10% SC) @ 0.025 kg a.i. /ha PoE (T10), 3 Hand weeding at 25, 40 and 55 DAS (T11) and Weedy check (T12) were laid out in randomized block design and replicated thrice. Rice variety "Sahbhagi dhan" was seeded directly using 80 kg seed/ ha in rows spaced at 20 cm on 22th June 2018 after basal application of fertilizer. Sesbania was direct line sown in soil using 40 kg seed/ ha after sowing of rice. Recommended dose of chemical fertilizer 80 kg N + 40 kg P_2O_5 + 20 kg K_2O/ha was applied through urea, diammonium phosphate and muriate of potash respectively. Half dose of nitrogen and full amount of phosphorus and potassium were applied in experimental field as basal. Rest half of nitrogen was applied in two splits as top dressing i.e. first top dressed at maximum tillering stage and second dressed at panicle primordial initiation. Sesbania was incorporated in the soil on 18thJuly 2018 at 5 weeks after sowing of sesbania. incorporation of sesbania was done by using spade. From sowing to emergence the soil was kept near moist but not saturated to avoid seed rotting. The field was saturated from three leaf stage to tillering, panicle initiation and grain filling stages to avoid water stress at these stages. However, at anthesis the excess water was drained out to avoid sterility.

The effective tillers m^2 at maturity stage was counted by placing a quadrate of 50 cm x 50 cm (0.25 m^2) randomly at two places in each plot and total no. of effective tillers m^2 was counted during experiment. The five panicles samples were collected randomly from each plot and their length was measured from base to tip of panicle and average values were calculated. Grains of five panicles selected for measuring number of grains $panicale^{-1}$ from each plot were counted carefully and averaged to obtain during investigation. The thousand grains randomly selected and counted from each plot. The counted grains were dried to 14% moisture and then weighed. The grains yield was obtained by straw and separation of cleared grain of each net plot was weighed in kg and finally makes in q/ha for statistical analysis. The straw yield kg/plot was calculated by subtracting grain yield kg/ plot of each net plot. The straw yield was converted into q/ha and analyzed. The harvest index is the ratio of grain yield and biological yield multiplied by 100.It was calculated by following formula–

$$\text{Harvesting Index (\%)} = \frac{\text{Grain Yield}}{\text{Grain Yield + Straw Yield}} \text{ X } 100$$

Cost of cultivation was calculated for different treatments with the prevailing market prices and it was worked out by considering all the expenses incurred in the cultivation of experimental crop and added with common cost due to various operations and inputs. Gross profit was calculated by multiplying the grain/seed and straw yield/ha with the prevailing market prices of seed and straw. Benefit-cost ratio was calculated by dividing the net return to the cost of cultivation of the individual treatment combination-

$$\text{B:C Ratio} = \frac{\text{Net return}}{\text{Cost of Cultivation}}$$

Results and Discussion

Effect on yield attributes

All weed management practices significantly improved the growth and yield attributes of direct seeded rice over weedy check (Table 1). The highest values of effective tillers (282 per m^2 at maturity), total grain per panicle (143 per panicle at maturity), fertile grain per panicle (122 per panicle at maturity) and 1000 grain weight (23.77 g) were recorded under 3 Hand weeding at 25, 40 and 55 DAS which was on par with Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS and Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS. The lowest data was observed in weedy check. The enhancement of yield attributes components could be due to less competition by the weeds for crop these factors throughout the crop growth period due to control of early emerged weeds before sowing through preemergence application of herbicides and late emerged weeds through hand weeding and post emergence application of herbicides. Similar results were reported by Prithvi *et al.,* (2015) [12].

Effect on yield

Among different weed management practices, 3 hand weeding at 25, 40 and 55 DAS observed significantly higher grain, straw yield and harvest index (41.70 q/ha 61.30 q/ha, and 40.49%, respectively) and recorded lowest weed index (0.00%) of direct seeded rice as compared to weedy check. However, it was on par with Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS and Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS (Table 2). The minimum Grain and straw yield in weedy check could be due to the severe weed competition as evidenced by the maximum weed density, weed dry matter which resulted in less number of tillers, lower plant dry matter and plant height. The greater remobilization of stem reserve towards the grain resulted in higher grain yield. Some amount of carbohydrates formed before flowering are stored in culms and leaf sheaths and later re-translocated to the grain (Reddy and Reddy, 2005) [13]. The results are in conformity with Daniel *et al.* (2012) [3], Walia *et al.* (2009) [14] and Mahajan and Timsuna (2011) who have also observed higher yield of rice owing to better integrated as

well as chemical methods of weed control in direct seeded rice. Whereas, significantly highest weed index was recorded by weedy check (83.98%). This might be due to better weed control efficiency of the pre-emergence application of herbicide with inter-culture and broad spectrum weeds control was reported by Poonguzhalan *et al.*, 2012 [11] and Prasad *et al.* (2016) [7].

Effect on economics

A critical analysis of data on economics revealed that the highest gross returns (Rs 85,228 per ha) was obtained with 3 hand weeding at 25, 40 and 55 DAS but also higher cost of cultivation in 3 hand weeding at 25, 40 and 55 DAS due to engagement of more labourers for weeding. This confirms the finding of Tuti *et al.*, (2016) [17]. Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS and Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS had reduced cost of cultivation compared to 3 hand weeding at 25, 40 and 55 DAS. Maximum net return (Rs. 61,864 per ha) and B:C ratio (2.94) were obtained with Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS, was comparable to Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS. The weedy check recorded significantly minimum net returns (Rs 2652 per ha) and B:C ratio (-0.14) (Table 3). The higher net returns in this treatment when compared to 3 hand weeding at 25, 40 and 55 DAS was not because of higher yield but because of lower cost involved in herbicide application and inter-culture than weed free plot. The results are corroborating with those reported by Yadav *et al.* (2018) [15] and Yogananda *et al.* (2017) [16].

Table 1: Effect of weed control treatments on yield attributes parameters of direct seeded rice

Treatments	Effective tillers/m^2	Total grain / panicle	Fertile grain / panicle	1000 grain weight (g)
T_1: Pendimethalin @ 0.75 kg a.i /ha (PE)	201	103	94	20.08
T_2: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 1Hand weeding at 25 DAS	225	119	108	21.14
T_3: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	245	120	113	21.95
T_4: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Sesbania incorporation 25 DAS	244	121	115	22.39
T_5: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS	258	125	118	22.75
T_6: Pretilachlor @ 1.00 kg a.i /ha (PE)	211	115	108	20.33
T_7: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 1Hand weeding at 25 DAS	242	119	112	21.35
T_8: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	244	121	115	22.15
T_9: Pretilachlor @ 1.00 kg a.i /ha (PE)*fb* Sesbania incorporation 25 DAS	250	122	116	22.60
T_{10}: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium@ 0.025 kg a.i/ha PoE 20 DAS	280	139	121	23.62
T_{11}: 3 Hand weeding at 25, 40 and 55 DAS	282	143	122	23.77
T_{12}: Weedy Check	110	64	52	19.03
SE m ±	9.66	5.37	3.06	1.03
CD (P = 0.05)	28.33	15.76	8.98	3.03
CV%	7.19	7.91	5.66	8.21

Table 2: Effect of weed control treatments on yield, harvest index and weed index parameters of direct seeded rice

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Weed index (%)
T_1: Pendimethalin @ 0.75 kg a.i /ha (PE)	23.07	36.68	38.61	44.67
T_2: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 1 Hand weeding at 25 DAS	27.97	44.21	38.76	32.93
T_3: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	32.12	50.06	39.08	22.97
T_4: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Sesbania incorporation 25 DAS	34.07	52.35	39.42	18.30
T_5: Pendimethalin (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS	35.66	53.02	40.22	14.48
T_6: Pretilachlor @ 1.00 kg a.i /ha (PE)	25.71	40.79	38.66	38.35
T_7: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 1Hand weeding at 25 DAS	30.90	48.62	38.86	25.90
T_8: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	33.00	50.83	39.37	20.85
T_9: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Sesbania incorporation 25 DAS	34.88	52.67	39.84	16.34
T_{10}: Pretilachlor @ 1.00 kg a.i/ha (PE) *fb* Bispyribac Sodium@ 0.025 kg a.i/ha PoE 20 DAS	40.52	60.09	40.27	2.81
T_{11}: 3 Hand weeding at 25, 40 and 55 DAS	41.70	61.30	40.49	0.00
T_{12}: Weedy Check	6.67	10.50	38.81	84.00
SE m ±	1.63	2.564	1.18	1.92
CD (P = 0.05)	4.78	6.51	NS	5.62
CV%	12.25	13.49	10.20	12.42

Table 3: Effect of weed control treatments on economics and B:C ratio of direct seeded rice

Treatments	Total Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_1: Pendimethalin @ 0.75 kg a.i /ha (PE)	18631	47709	29078	1.56
T_2: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 1Hand weeding at 25 DAS	24991	57785	32794	1.31
T_3: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	30079	66223	36144	1.20
T_4: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Sesbania incorporation 25 DAS	26937	70086	43149	1.60
T_5: Pendimethalin @ 0.75 kg a.i /ha (PE) *fb* Bispyribac Sodium @ 0.025 kg a.i/ha PoE 20 DAS	21490	73008	51518	2.40
T_6: Pretilachlor @ 1.00 kg a.i /ha (PE)	18211	53144	34933	1.92
T_7: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 1hand weeding at 25 DAS	24572	63793	39221	1.60
T_8: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* 2 Hand weeding at 25 and 40 DAS	29659	67922	38263	1.29
T_9: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Sesbania incorporation 25 DAS	25237	71579	46342	1.84
T_{10}: Pretilachlor @ 1.00 kg a.i /ha (PE) *fb* Bispyribac Sodium@ 0.025 kg a.i/ha PoE 20 DAS	21070	82934	61864	2.94
T_{11}: 3 Hand weeding at 25, 40 and 55 DAS	31687	85228	53541	1.69
T_{12}: Weedy Check	16423	13773	-2650	-0.16
SE m ±	-	3364	3364	0.11
CD (P = 0.05)	-	9864	9864	0.33
CV%	-	9.28	9.28	12.41

Conclusion

On the basis of one year experiment it may be concluded that application of Pretilachlor (50% EC) @ 1.00 kg a.i. /ha as pre-emergence *fb* Bispyribac sodium (10% SC) @ 0.025 kg a.i. /ha post-emergence with weed management cost of (Rs 4648 /ha) is effective in suppressing weed for higher crop growth, grain yield, net return and benefit: cost ratio of direct seeded rice under medium land condition of Jharkhand.

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