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Growth and Yield of Direct-Seeded Rice (*Oryza sativa*) as Influenced by Sowing Dates and Weed Management Methods

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Abstract

A field experiment was conducted during rainy seasons of 2007 and 2008 at Rajendra Agricultural University, Pusa, Bihar on sandy loam soil to study the response of sowing date and weed management methods on direct seeded rice The treatments included sowing date before onset of monsoon (22nd June) and after onset of monsoon (12th July). The weed management methods were Pretilachlor-s 0.5 kg ha^{-1}, Butachlor 1.5 kg ha^{-1} + 1 HW at 30 DAS, Fenoxaprop 60 g ha^{-1}, Sesbania (broadcast) + 2,4-D 0.5 kg ha^{-1} along with weed free and weedy check. All the growth attributing characters viz. plant height, tillers m^{-1} row length , LAI, CGR, NAR and dry matter accumulation were significantly higher in plots getting weed free environment closely followed by pre-emergence application of butachlor 1.5 kg ha^{-1} + 1 HW. Weed population and weed dry matter was the least under weed free check followed by *Sesbania* broadcast + 2, 4-D and Butachlor + 1 HW. However, highest WCE (87%) was in weed free check followed by Butachlor + IHW (80%) and *Sesbania* broadcast + 2,4-D (76.5%), which had statistical equality between them.

1. Introduction

Direct-seeded rice (*Oryza sativa* L.) is becoming popular in India as it is cheaper alternative to transplanting. The direct seeding could also help to endure the timely sowing in a stipulated time. But crop-weed competition in direct-seeded rice is more severe, reducing the yield by 20-95 % (Gogoi, 1995). Manual weeding is expensive, laborious and time consuming as well as difficult in early stage of crop growth. Use of pre-emergence herbicides has been found effective in early stage, but the second flush of weeds at 25 to 30 days after sowing (DAS) has become problematic. Various herbicides have been used for controlling weeds in direct-seeded rice but efficacy of chemical methods based on a single herbicide treatment may be unsatisfactory because of their narrow spectrum of weed control. Therefore, application of several herbicides in combination or sequence can be more useful. Keeping this in view, the present field investigation was carried out to test the response of sowing date and weed management methods on direct-seeded rice.

2. Materials and Methods

A field experiment was conducted at the Agronomic Research farm, Department of Agronomy, Rajendra Agricultural University, Pusa, (Samastipur), Bihar during rainy season of 2007 and 2008. The experiment was laid out in a split plot design with two sowing dates (22nd June and 12th July) in the main plots and six weed management methods (Pretilachlor @ 0.5 kg ha^{-1} as pre-em; Butachlor 1.5 kg ha^{-1} as pre-em + 1 HW at 30 DAS; Fenoxaprop 60 g ha $^{-1}$ at 30 DAS; *Sesbania* broadcast with seed rate of 25 kg ha $^{-1}$ before sowing of crop + 2, 4-D @ 0.5 kg ha^{-1} at 30 DAS; Weedy check and Weed free check) allocated to the sub-plots having three replications. The soil of the experimental plot was low in available N, P_2O_5 and K_2O and having soil reaction in the slightly alkaline range (8.2). Recommended doze of fertilizer (120, 30 and 30 kg N, P_2O_5 and K_2O ha $^{-1}$) was applied through urea, single super phosphate and muriate of potash. A common dose of 25 kg $ZnSO_4$ ha^{-1} was applied at the time of sowing. However, one third nitrogen and whole amount of P and K and Zn were applied at sowing and remaining dose of N was applied in two equal splits at 30 and 60 days after sowing. Rice variety BPT-5204 with the seed rate 80 kg ha^{-1} was sown on 22 June and 12 July respectively and

harvested in first fortnight of November during both the years. The sowing of direct-seeded rice was done by broadcasting the pre-sprouted seeds after puddling. The total rainfall received during crop season was 1206 and 1250 mm in the first and second years respectively. The direct seeded rice was kept moist during the first week to ensure its proper germination and water was not allowed to accumulate for avoiding seed rotting. Therefore, the irrigations were applied at 3 days after disappearance of ponded water throughout up to 15 days before harvesting. The subsequent irrigations were given 2 days after the ponded water was infiltrated into the soil. All the cultural operation like hand weeding was done manually with the help of shovel as per treatment and crop requirements.

3. Results and Discussion

3.1. Effect on weed

Weed population and weed dry matter accumulation were very marginally higher under 12th July sowings (Table 1). The effects of heavy rains on germination of plants in 22nd June sowing might have restricted growth of weeds due to submerged conditions invariably faced in the month of July when it rained very heavily. Weed control efficiency (WCE) was highest in the weed free treatment (87 %) which was at par with 80 % (Butachlor @1.5 kg ha^{-1}, pre-em + 1HW at 30 DAS) and 76.5 % (Sesbania broadcast + 2, 4-D @ 0.5 kg ha $^{-1}$30 DAS). in the weed management treatments. However, weed control efficiency was not affected significantly due to dates of sowing. Weed population, weed dry matter and weed control efficiency were the best in weed free check followed in descending order by Butachlor + 1 HW and *Sesbania* broadcast + 2, 4-D. The lower weed population and weed dry matter in the Butachlor @1.5 kgzha, pre-em + 1HW at 30 DAS treatment might be due to higher efficiency of butachlor and weed emerged after manual weeding at 30 DAS were suppressed by the crop to a great extent. The reasons ascribed to growth yield attributes and yields also explain the reasons for variation in weed intensity. The results of the current investigation also agree with the reports of Singh et al. (2005), Sanjay et al. (2008) and Maity and Mukherjee (2008).

Table 1: Effect of sowing date and weed management methods on weed population and weed dry weight

Treatments	Total weed count m^{-2}			Weed dry weight (g m^{-2})			WCE (%)
	90 DAS	90 DAS	90 DAS	0-30 DAS	30-60 DAS	60-90 DAS	
Sowing date							
D_1	42.85	104.04	157.83	13.78	102.00	113.33	72.20
D_2	44.85	109.80	160.67	13.97	110.83	121.33	72.80
CD (p=0.05)	1.82	0.31	NS	NS	4.39	NS	NS
Weed management methods							
W_1	45.20	113.83	179.50	16.95	112.50	125.00	58.00
W_2	40.65	45.00	85.00	15.95	51.50	58.00	80.00
W_3	39.40	105.50	164.50	14.35	105.50	115.00	61.00
W_4	26.35	42.50	94.50	9.50	62.00	69.00	76.50
W_5	94.50	319.50	409.00	19.20	274.50	300.50	-
W_6	17.00	15.20	23.00	7.30	32.50	36.50	87.00
CD (p=0.05)	4.32	11.64	12.98	1.47	10.42	16.40	11.94

D_1: Before onset of monsoon, 22nd June; D_2: After onset of monsoon, 12th July; W_1: Pretilachlor-s @ 0.5 kg ha^{-1} (PE 5 DAS); W_2: Butachlor @1.5 kg ha^{-1} (PE) + 1HW (30 DAS); W_3: Fenoxaprop @ 60 g ha^{-1} (POE 30 DAS); W_4: *Sesbania* (broadcast)+ 2,4-D @ 0.5 kg ha^{-1} at 30 DAS); W_5: Weedy check; W_6: Weed free

3.2. Effects on growth parameter

It is evident from the data (Table 2), the plant height, tillers m^{-1} row length, LAI and dry matter accumulation in plants were significantly higher in 22nd June sowing as compared to those under 12th July sowing. Crop growth rate (CGR) and net assimilation rates (NAR) were also higher in 22nd June sowing. However, the variations in growth parameters were more pronounced under the impact of weed management practices. Plant height was similar under the treatments- weed free check; pre-emergence application of butachlor 1.5 kg ha^{-1} followed by one hand weeding at 30 days after sowing; pre-emergence application of pretilachlor @ 0.5 kg ha^{-1}. However, tillers m^{-1} row length and dry matter accumulation in plants were the maximum in weed free check. Leaf area index was also at par in weed free check and butachlor + 1 HW. Pre-emergence application of butachlor + 1 HW had additional benefit of getting weed suppressing measure at two different growth stages which might have given greater impetus to plants under this treatment. *Sesbania* broadcast followed by the application

Table 2: Effect of sowing dates and weed management methods on growth attributes of direct seeded rice (pooled data of 2 years)

Treatments	Plant height (cm)	Tillers m^{-1} row length	Plant DW (g)	CGR ($g\ m^{-2}\ day^{-1}$)				NAR ($g\ m^{-2}\ day^{-1}$)		LAI		
	90 DAS	90 DAS	90 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-harvest	30-60 DAS	60-90 DAS	30 DAS	60 DAS	90 DAS
Sowing date												
D_1	84.85	55.40	110.83	0.84	1.67	1.17	1.99	0.97	0.36	1.00	2.83	3.51
D_2	84.57	54.10	101.17	0.81	1.48	1.08	1.83	0.82	0.33	0.97	2.92	3.42
CD (p=0.05)	0.18	0.20	NS	0.001	0.024	0.091	0.023	0.07	NS	0.20	0.022	NS
Weed management methods												
W_1	88.40	56.10	107.50	0.81	1.61	1.18	1.93	0.88	0.37	1.03	2.85	3.54
W_2	91.30	61.20	126.00	0.90	1.89	1.39	2.26	0.99	0.40	1.04	3.14	3.89
W_3	84.80	53.30	105.00	0.79	1.62	1.08	1.90	0.96	0.36	0.96	2.63	3.28
W_4	79.05	51.90	97.00	0.78	1.45	1.00	1.75	0.85	0.33	0.89	2.89	3.17
W_5	70.10	38.20	60.00	0.73	0.71	0.55	1.08	0.47	0.22	0.94	2.24	2.77
W_6	94.50	67.80	140.50	0.94	2.19	1.55	2.51	1.22	0.41	1.06	3.47	4.11
CD (p=0.05)	9.21	6.45	14.59	0.068	0.347	0.123	0.185	0.10	0.03	0.08	0.267	0.30

D_1: Before onset of monsoon, 22nd June; D_2: After onset of monsoon, 12th July; W_1: Pretilachlor-s @ 0.5 kg ha^{-1} (PE 5 DAS); W_2: Butachlor @1.5 kg ha^{-1} (PE) + 1HW (30 DAS); W_3: Fenoxaprop @ 60 g ha^{-1} (POE 30 DAS); W_4: *Sesbania* (broadcast)+ 2,4-D @ 0.5 kg ha^{-1} at 30 DAS); W_5: Weedy check; W_6: Weed free

of 2, 4-D at 30 DAS also got weed suppressing measure at two different growth stages. However, the luxuriant growth of *Sesbania* not only checked the weed growth and giving serious competition to weeds but they also might have suppressed the rice plant growth giving tough competition to them. The *Sesbania*, being a leguminous crop might have supplemented the rice plants with extra nitrogen through its nodules, but the benefits derived out of the increased nitrogen supply might have been overshadowed by the competition *Sesbania* gave to rice plants for light, space and carbon dioxide. Thus, the resultant effect might have gone against this treatment. The least variations resulting out of the variation in dates of sowing might be explained on the basis that the plants experienced almost similar conditions both in their vegetative and reproductive phases. The reproductive phase even under the 12th July sowing completed well before drop in the temperature which in general is expected to affect flowering and anthesis due to low temperature. The only difference in the two sowing dates might have faced variation in rainfall which had gone marginally in favour of 22nd June sowing. The results of the present investigation are also in conformity with the works of Maity and Mukherjee (2008).

3.3. Effects on yield attributes and yield

Yield attributing characters were not affected significantly due to dates of sowing. The panicle length and 1000-grain weight were also not affected significantly due to weed management practices. Number of panicles m^{-2} was significantly maximum (291) in weed free plots. Amongst the herbicides, maximum panicles m^{-2} (260) was recorded from pre-emergence application of butachlor at 1.5 kg ha^{-1} followed by one hand weeding at 30 DAS. The treatment involving *Sesbania* broadcast + 2, 4-D at 30 DAS although controlled weed effectively yet could not result in better growth, development and yields. The results obtained in terms of yield attributes also get able support in the works of Ravisankar et al. (2008), Subramanian and Martin (2006). Grain and straw yields and harvest index under the two dates of sowings also did not differ significantly. Amongst the weed management practices, the maximum grain yield (50 q ha^{-1}) was recorded under weed free check. Amongst the herbicidal treatments, pre-emergence application of pretilachor at 0.5 kg ha^{-1} gave the highest grain yield of 37.2 q ha^{-1}. However, it was at par with fenoxaprop @ 60 g ha^{-1} at 30 DAS yielding 33.5 q ha^{-1}. The results in terms of yield and harvest index are in agreement with those reported from Singh et al. (2005).

3.4. Economics

Gross return, net return and B : C ratio were higher in 22nd June sowing under all the conditions except that in case of weedy check it was the 12th July sowing which fetched higher gross return, net return and B : C ratio than the 22nd June sowings (Table 3). Both gross return (₹40,695 ha^{-1}) and net return (₹9945 ha^{-1}) were the maximum under the treatment combination of 22nd June sowing and weed free environment. This treatment combination was followed by 22nd June sowing and Butachlor + 1 HW which earned gross return of ₹6430 ha^{-1} and net return of ₹9460 ha^{-1}. The net returns earned by the aforesaid two treatment combinations were statistically alike. The B : C ratio was the maximum (1.14) under the treatment combination of 22nd June sowing and Butachlor +

Table 3: Effect of sowing date and weed management methods on yield attributes, yield and economics of direct seeded rice (pooled data of 2 years)

Treatments	Fertile panicles m^{-2}	Length of panicle (cm)	Grains $panicle^{-1}$	1000-grain wt.(g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Sowing date										
D_1	235	18.12	86.33	20.90	37.65	49.47	42.33	29419	13365	0.81
D_2	227	18.06	84.83	20.80	34.70	46.55	41.84	27210	11156	0.68
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	1409	508	0.029
Weed management methods										
W_1	234	18.25	84.50	20.85	37.20	49.25	42.50	29105	14490	0.99
W_2	260	18.45	92.00	21.05	44.40	56.55	43.50	34515	17545	1.03
W_3	220	18.25	84.00	20.70	33.50	45.95	41.50	26370	11905	0.81
W_4	218	18.20	82.50	20.65	32.55	44.70	41.50	25628	10103	0.64
W_5	160	16.70	74.00	20.50	19.40	29.00	39.53	1330	1510	0.10
W_6	291	18.70	96.50	21.35	50.00	62.60	44.00	38760	18010	0.86
CD (p=0.05)	27	NS	9.07	NS	5.05	8.68	NS	3341	1206	0.07

D_1: Before onset of monsoon, 22nd June; D_2: After onset of monsoon, 12th July; W_1: Pretilachlor-s @ 0.5 kg ha^{-1} (PE 5 DAS); W_2: Butachlor @1.5 kg ha^{-1} (PE) + 1HW (30 DAS); W_3: Fenoxaprop @ 60 g ha^{-1} (POE 30 DAS); W_4: *Sesbania* (broadcast)+ 2,4-D @ 0.5 kg ha^{-1} (30 DAS); W_5: Weedy check; W_6: Weed free

1 HW . The treatment combination next in order (1.09) was 22nd June sowing and Pre-emergence application of 0.5 kg ha^{-1} Pretilachlor. The treatment weed free check which headed almost all the tables took third place in respect of B: C ratio. The gross and net returns were the reflections of economic yields while B : C ratio also indicated cost of cultivation, which was higher in weed free check. The cost of weeding is comparatively higher than herbicidal applications. The result in respect of economics under the present investigation collaborates with the works of Singh and Namdeo (2004), Sanjay et al. (2008) and Maity and Mukherjee (2008).

4. Conclusion

Growth attributing characters such as plant height, tillers m^{-1} row length, LAI, CGR, NAR along with dry matter accumulation were significantly higher in plots getting weed free environment and was closely followed by pre-emergence application of butachlor @1.5 kg ha^{-1} + 1HW. Weed population and weed dry matter was the least under weed free check followed by *Sesbania* broadcast + 2, 4-D and Butachlor + 1 HW. Highest WCE (87%) was observed in weed free check followed by Butachlor + IHW (80%) and *Sesbania* broadcast + 2,4-D (76.5%), which had statistical equality between them. Higher gross return, net return and B : C ratio was recorded in 22nd June sowing as compared to the 12th July sowing. Among weed management treatments, next to weed free, Butachlor + 1 HW earned higher gross return (₹36430 ha^{-1}) and net return (₹19460 ha^{-1}).

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