Indian Journal of Weed Science 43 (3&4) : 139-144, 2011

Effects on production potential and economics of direct seeded rice sowing dates and weed management techniques

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ABSTRACT

Plant height, tillers/m row length, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and dry matter accumulation in plants were significantly higher in plots getting weed free environment closely followed by pre-emergence application of butachlor 1.5 kg/ha *fb* 1 HW. However, yield attributes *i.e.* panicles/m^2 and fertile grains/panicle and finally yield were significantly higher in weed free check with butachlor *fb* 1 HW closely on its heel. Among the nutrient concentration, it was only P in straw which was very marginally higher in weed free check and butachlor *fb* 1 HW. However, sowing date of 22nd June showed significantly higher N, P and K uptake by grain and straw. Weed population and weed dry matter were significantly higher in 12th July sown crop but least weed population, dry matter and good weed control efficiency were accounted with weed free check and butachlor *fb* 1 HW though the nutrient concentration were affected significantly both due to sowing date and weed management practices. Nutrient uptake due to weed was higher in 12th July sowing date. Amongst the weed management methods, the nutrient uptake of weeds were least in weed free check followed by butacholar *fb* 1 HW and *Sesbania* broadcast *fb* 2,4-D 0.5 kg/ha at 30 DAS. Similar results were also recorded in the case of gross return, net return and B :C ratio in case of 22nd June.

Key Words : Direct seeded rice, Herbicides, Nutrient uptake, Yield attributes, Economics, Cultural control.

Direct seeded rice (DSR) is becoming popular as it is cheap alternative to transplanting. But crop weed competition in the system is more severe, reducing grain yield by 20-95% (Gogoi 1995). Manual weeding is expensive, laborious and time consuming as well as difficult in early stage of crop growth. To make paddy cultivation cost effective, DSR provide an option which saves labour and water use. The direct seeding could also help to endure the timely sowing in a stipulated time. 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) becomes a problem. Heavy infestation of weeds is one of the major constraints for successful cultivation of DSR. However, success of DSR depends largely on effective weed control especially with chemical methods. Various herbicides have been used for controlling weeds in DSR but efficacy of chemical methods based on a single herbicide treatment may be unsatisfactory because of their narrow spectrum weed control. Therefore, application of several herbicides in combination or sequence can be more useful. Agronomic practices can also lower crop-weed competition and yield losses keeping this in view, the present field investigation was carried out to test the response of sowing dates and weed management techniques in DSR.

MATERIALS AND METHODS

A field experiment was conducted at the farm of Rajendra Agricultural University, Pusa, (Samastipur), Bihar during rainy seasons of 2007 and 2008. The experiment was laid out in split plot design with two sowing date (22nd June and 12th July) in the main plots and six weed management methods, *viz*., pre-emergence (PE) pretilachlor 0.5 kg/ha; PE butachlor 1.5 kg/ha *fb* 1HW; fenoxaprop 60 g/ha 30 DAS; *Sesbania* broadcast *fb* 2,4-D 0.5 kg/ha 30 DAS and 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 and K and having soil reaction in the slightly alkaline range (8.2). Recommended dose of N, P, K was applied at the rate of 120, 30 and 30 kg N, P and K/ha through urea, single super phosphate and muriate of potash. A common dose of 25 kg Zn SO^4/ha was applied at the time of puddling or sowing. However, one third nitrogen and whole amount of P and K and Zn were applied after puddling and remaining dose of N was applied in two equal splits at 30 and 60 DAS in direct seeded rice. Rice variety *BPT-5204* with the seed rate 80 kg/ha was sown on 22nd June and 12th July, respectively and harvested in first

fortnight of November during both the years. The sowing of DSR 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 to avoid seed rotting. Therefore, the irrigation was applied at three days after disappearance of ponded water throughout up to 15 days before harvesting, whereas in transplanted rice, continuous ponding of water was kept for the first 15 days for the better establishment of rice and to improve the efficacy of applied herbicides. The subsequent irrigations were given two days after the ponded water was infiltrated into the soil. All the cultural operations like hand weeding was done manually with the help of shovel as per treatment at 20th and 40th DAS and crop requirements.

RESULTS AND DISCUSSION

Effects on crop growth

The plant height, number of tillers/m row length, leaf area index **(**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 (Table 1). However, the variations in growth parameters were more pronounced under the impact of weed management practices. Plant height was similar under the treatments of weed free check, pre-emergence application of 1.5 kg/ha butachlor followed by one hand weeding at 30 DAS and PE pretilachlor 0.5 kg/ha. These three treatments had comparatively taller plants than the other treatments. However, number of tillers/m row length and dry matter accumulation in plants were maximum in weed free check. The treatments next in descending orders were butachlor *fb*1 HW and pretilachlor applications. Leaf area index (LAI) was also more or less similar in weed free check and butachlor *fb* 1 HW. The least values for all of the above referred growth characters were noted under weedy check. Both CGR and the NAR were significantly more under weed free environment. The treatment next in this regards was PE butachlor 1.5 kg/ha *fb* 1 HW at 30 DAS. These two treatments had higher CGR and NAR than the other treatments. Better expression of growth parameters under the conditions in which plots were kept weed free is self explanatory. The treatment *Sesbania* broadcast followed by the application 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, but also provided serious competition to weeds, though they also might have suppressed rice plant growth giving tough competition.

Leguminous crop *Sesbania* through its nodules also might have supplemented rice plants with extra nitrogen, 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 reproductive phase even under the 12th July sowing completed well before the 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 been due to variation in rainfall which might have gone marginally in favour of 22nd June sowing (Maity and Mukherjee 2008).

No yield attributing characters were affected significantly due to dates of sowing. The panicle length and 1000-grain weight too were not affected significantly due to weed management practices (Table 2). So far as panicles/m^2 was concerned, it was significantly maximum (290.5) in the plots where plants experienced weed free environment. Amongst the herbicides treatments, maximum panicles/m^2 (260) were recorded from the plots getting pre-emergence application of 1.5 kg/ha butachlor followed by 1 HW at 30 DAS. These two treatments had higher panicles per unit area than the rest of the treatments. However, grains per panicle were also higher in the above two treatments, having been adjudged at par themselves, than the rest of the treatments. The control weedy check had significantly the least panicles/m (160) and fertile grains per panicle (74). The number of grains per panicle under weed free check and butachlor *fb*1 HW was 96.2 and 92, respectively.

The effect of dates of sowing, in general, relates to the climatic conditions met with during the vegetative and reproductive phases of crop growth. So far as vegetative phase was concerned, the maximum and minimum temperatures were in the congenial range for both the dates of sowings. These were more or less similar from July to September. The 22nd June sowing got greater quantum of rainfall after transplanting than the 12th July sowing which might have gone in its favour as the semi aquatic nature of rice loves to grow under submerged conditions. Normally an early sown variety of medium maturity may face adverse situations due to heavy rains at its flowering and anthesis stages. But even the 22nd June sowing did not experience any such situation helping it marginally in growth and development. In general, when, the late sown crop enters its reproductive phase in later part of October, the temperature starts falling abruptly due to which flowering and anthesis in rice are badly affected. However, during October in the year 2008, the temperature did not show any abrupt drop which might have gone in favour of

Table 1. Effect of sowing date and weed management techniques on growth attributes of direct seeded rice (pooled data of two years) at different days after sowing (DAS)

Treatments	Plant height (cm)				Tillers/m^2				Plant dry weight (g)				CGR (g/m^2/day)				NAR (g/m^2/day)			LAI	
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	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- Before onset of monsoon, (22nd June)	24.9	64.6	84.9	84.6	28.2	49.9	55.4	51.4	25.5	75.5	110.8	170.6	0.8	1.7	1.2	2.0	1.0	0.4	1.0	2.8	3.5
D_2- After onset of monsoon, (12thJuly)	24.9	64.6	84.6	84.3	27.7	48.3	54.1	49.8	24.3	68.8	101.2	156.0	0.8	1.5	1.1	1.8	0.8	0.3	1.0	2.9	3.4
LSD (P=0.05)	NS	NS	0.2	NS	NS	0.2	0.2	0.2	NS	NS	NS	7.4	0.1	0.0	0.1	0.0	0.1	NS	0.2	0.0	NS
Weed management methods																					
W_1- Pretilachlor 0.5 kg/ha (PE 5DAS)	25.5	67.6	88.4	88.2	29.2	50.4	56.1	51.5	24.6	72.0	107.5	165.7	0.8	1.6	1.2	1.9	0.9	0.4	1.0	2.9	3.5
W_2- Butachlor1.5 kg/ha (PE) *fb* 1HW (30 DAS)	25.8	69.4	91.3	91.0	29.5	55.3	61.2	56.7	27.2	84.0	126.0	194.0	0.9	1.9	1.4	2.3	1.0	0.4	1.0	3.1	3.9
W_3- Fenoxaprop 60 g/ha (POE 30 DAS)	24.9	64.1	84.8	84.7	27.6	43.3	53.3	48.9	23.8	72.5	105.0	162.0	0.8	1.6	1.1	1.9	1.0	0.4	1.0	2.6	3.3
W_4- *Sesbania* (broadcast)+2,4-D 0.5 kg/ha at 30 DAS)	24.1	60.4	79.1	78.8	24.6	46.2	51.9	48.0	23.5	67.0	97.0	149.5	0.8	1.5	1.0	1.8	0.9	0.3	0.9	2.9	3.2
W_5- Weedy check	23.4	52.9	70.1	69.9	27.2	34.3	38.2	35.7	22.0	43.5	60.0	92.5	0.7	0.7	0.6	1.1	0.5	0.2	0.9	2.24	2.8
W_6- Weed free	25.7	73.0	94.5	94.2	29.7	61.0	67.8	62.8	28.2	94.0	140.5	216.0	0.9	2.2	1.6	2.5	1.2	0.4	1.1	3.47	4.1
LSD(P=0.05)	NS	8.0	9.2	10.8	3.3	5.3	6.5	4.58	2.7	11.7	14.6	9.4	0.1	0.4	0.1	0.2	0.1	0.1	0.1	0.27	0.3

LAI - Leaf area index

Table 2. Effect of sowing date and weed management techniques on yield attributes and yield of direct seeded rice (pooled data of two years)

Treatments	Fertile panicles/m^2	Length panicle (cm)	Grains/ panicle	1000- grain wt.(g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)
Sowing date							
D_1 - Before onset of monsoon, (22nd June)	234.5	18.1	86.3	20.9	3770	4950	42.3
D_2 - After onset of monsoon, (12th July)	227.0	18.1	84.8	20.8	3470	4660	41.8
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
Weed management methods							
W_1 - Pretilachlor) 0.5 kg/ha (PE 5DAS)	234.0	18.3	84.5	20.9	3720	4930	42.5
W_2 - Butachlor 1.5 kg/ha (PE) *fb* 1HW (30 DAS)	260.0	18.5	92.0	21.1	4440	5660	43.5
W_3 - Fenoxaprop 60 g/ha (POE 30DAS)	220.0	18.3	84.0	20.7	3350	4600	41.5
W_4 - *Sesbania* (broadcast)+2, 4-D 0.5 kg/ha at 30 DAS	218.0	18.2	82.5	20.7	3260	4470	41.5
W_5 - Weedy check	160.0	16.7	74.0	20.5	1940	2900	39.5
W_6 - Weed free	290.5	18.7	96.5	21.4	5000	6260	44.0
LSD (P=0.05)	26.8	NS	9.1	NS	510	870	NS

the 12th July sowing. As a result, the two sowing dates did not differ markedly in respect of growth, development and yield. The 1000-grain weight was not affected significantly by any of the factors studied.Superiority of hand weeding over herbicidal control, especially during rainy season is an established fact. The weedy check and butachlor *fb* 1 HW excelled over the other treatments. 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. On the other hand, fenoxaprop was applied at 30 DAS leaving the plots unattended in earlier growth stage. All the aforesaid factors combined together fully explain the yield behavior under the weed management practices (Ravisankar *et al*. 2008, Subramanian and Martin 2006).

Commensurating with the growth and yield attributing characters, the 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 (5000 kg/ha) was recorded under weed free check; butachlor *fb* 13 HW yielding 4440 kg/ha was inferior to weed free check but superior to rest of the treatments. Amongst the treatments solely restricted to herbicidal application, the application of 0.5 kg/ha PE- pretilachor gave the highest grain yield of 3720 kg/ha. However, it had statistical similar to fenoxaprop 60 g/ha at 30 DAS yielding 3350 kg/ha. So far as straw yield was concerned, the treatments weed free check and butachlor *fb* 1 HW did not vary significantly. Butachlor *fb* 1HW in its own turn was also comparable with pretilachlor. Significantly the least grain and straw yields were recorded under the control weedy check. Growth characters are the foundation on which the yield attributes are laid on and the sum total of yield attributes is ultimately reflected in economic yields. (Table 2). The yields under the two dates of sowings did not differ significantly. Broadly, it is the lowering temperature in later part of October which invariably affects flowering and anthesis of medium and late duration varieties of rice. However, even the flowering and anthesis in 12th July sowing completed before drop in temperature warding off any adverse effect of late sowing. The effect of weed management practices have also been explained in details earlier, which might have been the reasons for higher yields under the treatments involving hand weeding (Singh *et al*. 2005).

Nutrient uptake

Although, amongst N, P and K concentrations in grain and straw it was only P in straw which was marginally higher in weed free check and butachlor + 1 HW than *Sesbania* broadcast + 2,4-D and weedy check (Table 3). All other nutrients did not differ significantly for their concentrations in grain and straw. The N, P and K concentration in grain and straw does not appear to be a function of dates of sowing and weed management methods. Since, the available N, P and K were at the same level for all the treatments these might not have differed significantly. The P and K uptake in grain and K uptake in straw were higher in 22nd June sowing. The variations clearly related to the variations in yields and not due to the concentration of nutrients. The N, P and K uptakes both in grain and straw were higher in plots experiencing weed free environment. The next best treatment in order was butachlor *fb* 1 HW (Singh and Patel 1989).

Effect on weeds

Weed population and weed dry matter accumulation were marginally higher under 12th July sowings (Table 4). The heavy rains affecting 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 rains very heavily. However, weed control efficiency was not affected significantly due to dates of sowing. Nutrient concentrations too as not affected by date of sowings. Nutrient uptake by weed which appeared to be mainly the fraction of weed dry matter was higher in 12th July sowing. Weed population, weed dry matter and weed control efficiency were better in weed free check followed in descending order by butachlor *fb* 1 HW and *Sesbania* broadcast + 2, 4-D. Nutrients concentrations in weeds were also not affected significantly by weed management practices. Falling quite in the lines of weed dry matter, the nutrients removal by weeds were the least in weed free check followed by butachlor *fb* 1 HW and *Sesbania* broadcast + 2, 4-D. The reasons ascribed to growth yield attributes and yields also explain the reasons for variation in weed intensity and nutrients removal under them (Singh and Tripathi 2007).

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. Both gross return (Rs 40,695/ha) and net return (Rs 19,945/ha) were maximum under the treatment combination of 22nd June sowing and weed free environment (Table 5). This treatment combination was followed by 22nd June sowing and butachlor *fb* 1 HW which earned gross return of Rs 36,430/ha and net return of Rs 19,460/ha. The net return earned by the aforesaid two treatment combinations was statistically similar. The B: C

Table 3. Effect of sowing date and weed management techniques on nutrient concentration their uptake in grain and straw of direct seeded rice (pooled data of two years)

Treatments	Nutrient concentration (%)						Nutrient uptake (kg/ha)					
	Grain			Straw			Grain			Straw		
	N	P	K	N	P	K	N	P	K	N	P	K
Sowing date												
D1 - Before onset of monsoon, (22nd June)	1.5	0.3	0.5	0.5	0.1	2.1	49.8	8.6	18.2	22.3	4.7	91.6
D2 - After onset of monsoon, (12th July)	1.5	0.3	0.5	0.5	0.1	2.0	45.0	8.0	16.0	22.0	4.3	85.7
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	0.4	0.6	NS	NS	4.4
Weed management methods												
W1 - Pretilachlor 0.5 kg/ha (PE 5DAS)	1.5	0.3	0.5	0.5	0.1	2.0	48.2	8.6	17.0	19.9	4.5	90.7
W2 - Butachlor 1.5 kg/ha (PE) *fb* 1HW (30 DAS)	1.5	0.3	0.5	0.5	0.1	2.1	60.5	10.2	20.6	27.0	5.6	104.6
W3 - Fenoxaprop 60 g/ha (POE 30DAS)	1.5	0.3	0.5	0.5	0.1	2.1	43.5	7.7	18.0	21.7	4.2	84.8
W4 - *Sesbania* (broadcast) + 2, 4-D 0.5 kg/ha at 30 DAS	1.5	0.3	0.5	0.5	0.1	2.1	42.4	7.5	15.0	21.3	4.3	83.6
W5 - Weedy check	1.5	0.3	0.5	0.5	0.1	2.01	24.7	4.4	8.6	13.2	2.4	52.6
W6 - Weed free	1.5	0.3	0.5	0.5	0.1	2.05	65.1	11.6	23.3	29.9	6.2	115.8
LSD (P=0.05)	NS	NS	NS	NS	0.0	NS	1.6	1.0	2.1	2.0	0.5	10.4

Table 4. Effect of sowing date and weed management techniques on growth , plant population, dry matter accumulation nutrient content and their uptake of weed in direct seeded rice

Treatments	Total weed count/m^2 at different DAS			Weed dry weight (g/m^2) at different DAS			Nutrient content (%) in weeds			Nutrient uptake (kg/ha) by weeds			Weed control efficiency (%)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	N	P	K	N	P	K	
Sowing date													
D1 - Before onset of monsoon, (22nd June)	42.9	104.0	157.8	13.8	102.0	113.3	1.37	0.29	1.94	15.6	3.3	22.0	72.20
D2 - After onset of monsoon, (12th July)	44.9	109.8	160.7	14.0	110.8	121.3	1.38	0.28	1.94	16.8	3.6	23.5	72.80
LSD (P=0.05)	1.8	0.3	NS	NS	4.4	NS	NS	NS	NS	0.6	0.1	1.0	NS
Weed management methods													
W1 - Pretilachlor 0.5 kg/ha (PE 5DAS)	45.2	113.8	179.5	17.0	112.5	125.0	1.38	0.29	1.94	17.1	3.6	24.3	58.00
W2 - Butachlor 1.5 kg/ha (PE) *fb* 1HW (30 DAS)	40.7	45.0	85.0	16.0	51.5	58.0	1.37	0.28	1.95	8.0	1.7	11.3	80.00
W3 - Fenoxaprop 60 g/ha (POE 30DAS)	39.4	105.5	164.5	14.4	105.5	115.0	1.39	0.29	1.94	16.0	3.4	22.3	61.00
W4 - *Sesbania* (broadcast) + 2, 4-D 0.5 kg/ha at 30 DAS	26.4	42.5	94.5	9.5	62.0	69.0	1.38	0.29	1.94	9.6	2.0	13.4	76.50
W5 - Weedy check	94.5	319.5	409.0	19.2	274.5	300.5	1.38	0.30	1.92	41.5	9.1	57.9	
W6 - Weed free	17.0	15.2	23.0	7.3	32.5	36.5	1.37	0.27	1.95	5.0	1.0	7.2	87.00
LSD (P=0.05)	4.3	11.6	13.0	1.5	10.4	16.4	NS	N	NS	1.3	0.3	2.4	11.94

ratio was the maximum (1.14) under 22nd June sowing and butachlor *fb* 1 HW. The treatment combination next in order (1.09) was 22nd June sowing and pre-emergence application of 0.5 kg/ha pretilachlor. The treatment weed free check which headed almost all the tables took third place in respect of B:C ratio. Although, 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 (Sanjay *et al*. 2008).

Table 5. Effect of sowing date and weed management techniques on gross return, net return and B :C ratio of direct seed rice (pooled data of 2 years)

Sowing date	Gross return (Rs)			Net return (Rs)			B:C ratio		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
Weed Management Methods									
W_1 - Pretilachlor 0.5 kg/ha (PE 5DAS)	30580	27630	29105	15965	13015	14490	1.09	0.89	0.99
W_2 - Butachlor 1.5 kg/ha (PE) *fb* 1HW (30 DAS)	36430	32600	34515	19460	15630	17545	1.14	0.92	1.03
W_3 - Fenoxaprop 60 g/ha (POE 30DAS)	27865	24875	26370	13400	10410	11905	0.92	0.71	0.81
W_4 - *Sesbania* (broadcast) + 2, 4-D 0.5 kg/ha at 30 DAS	26765	24490	25628	11240	8965	10102	0.72	0.57	0.64
W_5 - Weedy check	14180	16840	15510	180	2840	1510	0.01	0.20	0.10
W_6 - Weed free	40695	36825	38760	19945	16075	18010	0.96	0.77	0.86
LSD (P = 0.05)	29419	27210	28315	13365	11156	12260	0.81	0.68	0.74
Sowing date		1409			508			0.03	
Weed management methods		3341			1206			0.07	
Interaction									
W at same D		3825			1705			0.10	
D at same W		3581			1617			0.09	

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