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Effect of herbicidal weed management in direct-seeded rice (*Oryza sativa*) and its residual effect on succeeding lentil (*Lens culinaris*)

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ABSTRACT

A field experiment was conducted during wet and dry seasons of 1995–97 to study the effect of herbicidal weed-management practices in controlling weeds in rice (*Oryza sativa* L.) and its residual effect on the succeeding lentil (*Lens culinaris* Medikus) in rainfed lowlands. Pre-emergence mixture of anilofos+2,4–DEE (0.3+0.5 kg a.i./ha) followed by 1 hand-weeding at 40 days after sowing in rice recorded the lower population and dry weight of weeds significantly compared with butachlor and pendimethalin in both crops. Weedy check till maturity in rice reduced the grain yield of rice by 50.1% compared to weed-free till maturity. The yield of succeeding lentil was the highest in the plots of rice which received anilofos + 2,4-DEE as pre-emergence and 1 hand-weeding at 40 days after sowing. This treatment also gave the higher benefit : cost ratio (2.50).

Key words : Weed management, Direct-seeded rice, Lentil, Residual effect, Rainfed lowland

In direct-seeded rice, problem of weeds is severe due to germination of crop and weeds simultaneously. Lentil is one of the important grain legumes and cultivated under a wide range of agro-ecological, cropping system and management variables. It is oftenly grown on the conserved moisture after rice.

The present experiment was conducted to study the efficacy of pre-emergence mixture with sequentially applied herbicide (post-emergence) or supplimented by hand-weeding in controlling weeds in direct-seeded rice and its carry-over effect on succeeding lentil crop in rainfed lowlands of Uttar Pradesh.

MATERIALS AND METHODS

The field experiment was conducted during the wet season and dry season of 1995–97. The soil was sandy loam having organic carbon 0.41%, with pH 8.1, available N 234 kg/ha, P_2O_5, 21 and K_2O 208 kg/ha. Fifteen treatments comprising weedy check till maturity (T_1); hand-weeding twice [20 and 40 days after sowing

(DAS)] (T_2); butachlor + 2, 4–DEE (1.0+0.6 kg a.i./ha) as pre-emergence (T_3); butachlor (1.0 kg a.i./ha) as pre-emergence + 1 hand-weeding 40 DAS (T_4); butachlor + 2, 4 DEE (0.75 + 0.5 kg a.i./ha) as pre-emergence followed by 2,4-DEE (0.5 kg a.i./ha) as post-emergence (25 DAS) (T_5); butachlor + 2,4–DEE (0.75 + 0.5 kg a.i./ha) as pre-emergence + 1 hand weeding 40 DAS (T_6); anilofos+2,4–DEE (0.3+0.4 kg a.i./ha) as pre-emergence (T_7); anilofos (0.4 kg a.i./ha) as pre-emergence + 1 hand-weeding 40 DAS (T_8); anilofos + 2, 4–DEE (0.3 + 0.5 kg a.i./ha) as pre-emergence followed by 2, 4–DEE (0.5 kg a.i./ha) as post-emergence (25 DAS) (T_9); anilofos+2,4–DEE (0.3+0.5 kg a.i./ha) as pre-emergence + 1 hand- weeding 40 DAS (T_{10}); pendimethalin + 2, 4–DEE (1.0 + 0.6 kg a.i./ha) as pre-emergence (T_{11}); pendimethalin (1.0 kg a.i./ha) as pre-emergence + 1 hand-weeding 40 DAS (T_{12}); pendimethalin + 2,4–DEE (0.75 + 0.5 kg a.i./ha) as pre-emergence followed by 2,4–DEE (0.5 kg a.i./ha) as post emergence (25 DAS) (T_{13}); pendimethalin + 2, 4 DEE (0.75 + 0.5 kg a.i./ha) as pre-emergence + 1 hand-weeding 40 DAS (T_{14}); and weed-free till maturity (T_{15}) were laid out in randomized block design with 3 replications.

All herbicides were sprayed using 600 litres water as per treatments in weed-free treatment. The removal of weeds was started from day 4 of sowing to till maturity of rice. While in rest of the treatments, the weeds were not removed after specific treatment. Rice variety 'Mahsuri' was direct-seeded in lines at 25 cm row using 100 kg seed/ha. The rice crop was fertilized @ 100 kg N + 50 P_2O_5 + 40 K_2O kg/ha. The full dose of P_2O_5 and K_2O and half dose of N were top-dressed in 2 splits, i.e. tillering and panicle-initiation stage of rice. The plot size was kept 20 m^2.

The experimental site was unchanged during both years and lentil was sown first week of December during both years between 2 rows of rice by narrow-tyned *kudali* without tillage. Lentil was fertilized @ 15 kg N/ha and top-dressed 40 days after its germination.

The density and dry weight of weeds were recorded from 0.25 m^2 quadrat placed randomly at 3 placed in each plot. In case of observation on weeds, the normality of distribution was not seen and hence the values were subjected to $\sqrt{X + 0.5}$ transformed prior to statistical analysis.

The visual crop toxicity rating was recorded at 25 days after sowing using rating scale of no toxicity to crop=0, and complete kill=10.

In the cropping system, no definite methodology is yet available for estimating the carry-over effect of the treatments imposed in the first crop on the succeeding crop in a sequence. The weed population and their dry weight in both rice and succeeding lentil, grain and straw yields of lentil were taken into consideration for estimating the carry-over effect of weed-management practices applied in rice on succeeding lentil crop. The plot-wise differences between direct-seeded rice and lentil for the above parameters were estimated and statistical analysis performed for drawing inferences as suggested by Choudhary (1989).

The total rainfall received during wet

season (end June to end November), and winter season (December to April) was 845.4 mm and 114.4 mm during 1995, and 743.6 mm and 133.0 mm during 1996. The other weather parameters like temperature, humidity and moisture content were found to quite favourable for both rice and lentil crops.

RESULTS AND DISCUSSION

The major weed species of the experimental site in rice were *Echinochloa crus-galli* (L.) Beauv., *E. colonum* (L.) Link, *Leptochloa chinensis* (L.) nees, and *Cynodon dactylon* L. among grasses; *Cyperus rotundus* L., *Cyperus difformis* L. and *Fimbristylis dichotoma* (L.) Vahl. among sedges; and *Caesulia axillaris* Roxb.; *Commelina benghalensis* L. and *Cynotis axillaris* among the broad-leaved weeds. *Chenopodium album* L., *Melilotus alba* Pers., *Melilotus indica* L., *Phalaris minor* Retz., *Fumaria parviflora* L., *Anagallis arvensis* L. and *Cryperus rotundus* L. were the major weed species infesting lentil.

Weeds and weed-control efficiency

All the weed-management treatments reduced the population and dry weight of weeds significantly compared with weedy check till maturity (T_1) in both years (Table 1). Treatments T_{10} and T_2 were at par with T_6 and T_8 but recorded significantly lower population of weeds than rest of the treatments in both the years. Pre-emergence mixture of anilofos, butachlor and pendimethalin with 2,4-DEE recorded the weed-control efficiency 63,69 and 60% respectively, which was lower than their rest of combinations. Higher weed-control efficiency recorded with hand-weeding twice (T_2) and anilofos + 2,4–DEE supplemented with hand-weeding at 40 DAS (T_{10}) was mainly due to lower dry weight of weeds. Similar results were reported by Behra and Jena (1997). The post-emergence spray of 2,4-DEE in treatments T_5,T_9, T_{13} reduced the density and dry weight of weeds significantly compared with the application of pre-emergence mixture of anilofos, butachlor and pendimethalin with 2,4–DEE during both years (Table 1). This reduction in density and dry weight of weeds could be attributed to the efficient control of late-emerging weeds.

The hand-weeding twice and all the combinations of anilofos recorded no toxicity to rice. Pendimethalin showed higher toxicity in rice, followed by butachlor. The highest toxicity (3.0 and 3.5 was recorded in 1995 and 1996 with pre-emergence application of pendimethalin + 2,4–DEE, followed by 2,4–DEE as post-emergence.

Among the herbicidal treatments, pre-emergence application of anilofos + 2,4–DEE (0.3 + 0.5 kg a.i./ha) supplemented with 1 hand-weeding at 40 DAS (T_{10}) gave significantly higher panicles/m^2, grain and straw yields. Weedy check recorded the lower number of panicles and grain and straw yields.

The reduction in the grain yield due to weedy check was 50.1%. Weed-free till maturity gave significantly higher grain yield in 1995 and in 1996 over rest of the treatments. The higher grain yield in above treatment, could be attributed to more panicles/m^2, and lower density and dry

Table 1. Weed population, weed dry weight, weed-control efficiency, panicles/m², grain and straw yields of rice as affected by weed-management treatments

Treatment	Weed population (No./m²) (90 DAS)		Weed dry weight (q/ha)		Weed control efficiency (%)	Panicles/ m²	Grain-yield (q/ha)		Straw yield (q/ha)		Crop toxicity rating
	1995	1996	1995	1996			1995	1996	1995	1996	
T_1	256 (16.0)	282 (16.8)	41.8	42.4		188	16.8	18.1	28.3	31.4	
T_2	34 (5.9)	38 (6.2)	5.7	6.4	86.6	321	32.8	30.1	45.6	41.9	1.00
T_3	130 (11.4)	144 (12.0)	14.8	16.1	63.0	220	25.5	22.9	35.3	31.7	1.75
T_4	46 (6.8)	50 (7.1)	8.7	10.1	77.6	266	30.7	27.1	42.8	37.9	1.50
T_5	114 (10.7)	126 (11.2)	9.0	12.2	74.6	243	26.9	23.6	37.3	32.8	2.00
T_6	42 (6.5)	46 (6.8)	7.3	8.5	81.0	293	31.8	28.1	44.6	39.6	1.75
T_7	124 (11.1)	136 (11.7)	12.2	13.7	68.9	227	26.8	23.2	36.9	32.0	1.00
T_8	42 (6.5)	46 (6.8)	7.2	8.0	81.9	276	31.8	27.2	44.2	37.9	1.00
T_9	110 (10.5)	122 (11.0)	9.7	10.6	75.6	253	27.7	23.9	38.0	33.0	1.00
T_{10}	34 (5.9)	33 (6.2)	6.7	7.2	83.4	314	32.5	29.9	45.2	41.2	1.00
T_{11}	134 (11.6)	148 (12.2)	16.1	17.1	60.3	210	25.7	22.5	36.7	31.3	3.00
T_{12}	56 (7.9)	62 (7.9)	10.3	11.9	73.4	255	29.3	27.4	40.8	38.3	2.25
T_{13}	118 (10.9)	130 (11.4)	12.4	13.4	69.6	234	26.6	23.4	37.0	32.6	3.25
T_{14}	64 (8.0)	72 (8.5)	8.3	9.4	78.8	280	31.5	28.7	44.5	40.6	2.75
T_{15}						328	34.7	33.7	47.9	46.7	
CD (P = 0.05)	1.0	0.80	1.2	0.70	3.3	10	2.3	4.0	3.0	5.2	
CV (%)	12.3	13.4	11.5	10.3	13.1	12.6	11.5	12.4	13.3	14.3	

Details of treatments are given under Materials and Methods

Table 2. Weed population/m², and dry weight, weed-control efficiency (at 50 days) and lentil yield as affected by weed-control treatments applied to rice

Treatment	Weed population/ m²		Weed dry weight (q/ha)	Weed-control efficiency (%)	Grain yield (q/ha)		Straw yield (q/ha)		Benefit : cost ratio
	1995	1996			1995	1996	1995	1996	
T_1	495 (22.3)	483 (23.9)	13.8		9.5	9.7	11.3	13.0	1.9
T_2	341 (18.5)	309 (17.6)	9.1	34.0	10.3	11.0	12.4	13.5	2.2
T_3	379 (19.5)	364 (19.4)	12.6	8.7	9.9	9.8	12.4	12.6	2.3
T_4	363 (19.1)	374 (18.4)	10.7	22.4	9.9	10.1	12.6	12.9	2.2
T_5	371 (19.3)	352 (17.9)	11.5	16.7	9.7	10.1	12.4	13.0	2.3
T_6	354 (18.8)	332 (19.0)	9.9	28.3	10.1	10.7	13.0	13.2	2.4
T_7	359 (19.0)	338 (18.4)	11.7	15.2	9.8	10.2	12.7	12.9	2.3
T_8	334 (18.3)	312 (16.7)	10.0	27.5	10.1	10.8	13.1	13.2	2.3
T_9	351 (18.7)	307 (17.5)	10.5	23.9	10.0	10.6	12.9	13.0	2.4
T_{10}	318 (17.8)	290 (16.4)	9.4	31.9	11.0	11.0	13.3	13.4	2.5
T_{11}	375 (19.4)	351 (18.8)	13.4	2.9	9.5	9.5	12.0	12.6	2.0
T_{12}	349 (18.7)	323 (18.2)	11.4	17.4	9.7	9.7	12.5	12.9	2.0
T_{13}	364 (19.1)	351 (18.5)	12.2	11.6	9.6	9.6	12.4	12.8	2.1
T_{14}	336 (18.3)	314 (16.7)	10.5	23.9	10.0	9.8	12.9	12.7	2.2
T_{15}	317 (17.8)	299 (17.3)	9.0	34.8	11.0	11.8	12.7	14.0	2.1
CD (P = 0.05)	1.3	1.3	0.40	3.7	1.1	1.4	1.0	1.0	
CV (%)	10.5	11.7	12.2	11.8	10.3	9.9	8.9	10.8	

Details of treatments are given under Materials and Methods

weight of weeds. Higher grain and straw yields under treatment T_{10} or T_8 was mainly because of lower weed population and dry weight which offered better crop–weed competition in favour of crop resulted in higher yield of rice. These findings are in close conformity with those of Tuteja *et al.* (1995) and Moorthy (1997). Post-emergence application of 2,4–DEE @ 0.5 kg a.i /ha increased the grain yield over pre-emergence herbicide mixture alone treatments which was because of efficient control of late-emerging weeds with post-emerence 2,4–DEE.

Residual effect

The residual effect on succeeding lentil was found significant. Pre-emergence application of anilofos + 2, 4 DEE (0.3 + 0.5 kg a.i./ha) supplemented by 1 hand-weeding at 40 DAS (T_{10}) to rice reduced the population and dry weight of weeds in lentil significantly, indicating its increased carry-over effect in suppressing weed population with significant increase in yields of lentil (Table 2). Moody *et al.* (1983) in rice–rice cropping sequence reported that plots with best weed control in the first crop recorded lower weed weight and higher seed yield in the second crop. Pre-emergence herbicide mixture followed by post-emergence 2,4–DEE to rice recroded the lower population and dry weight of weeds and higher grain yield of lentil over pre-emergence herbicide mixture alone.

Application of anilofos, butachlor and pendimethalin followed by 1 hand-weeding at 40 DAS (T_4, T_8, T_{12}) in rice also recorded the lower weed population and higher yield of succeeding lentil revealing the increased carry-over effect. Rajendran and Kempuchetaly (1998) recorded the minimum population and dry weight of weeds and higher yield of succeeding groundnut in plots of rice received pre-emergence herbicide followed by 1 hand-weeding or herbicide mixture (pre-emergence)-followed by 2,4-DEE as post-emergence.

Economics

The benefit : cost ratio of rice–lentil sequence was higher under treatment T_{10}, followed by T_9 and T_6. The higher return in these treatments was mainly owing to higher grain yield of rice and succeeding lentil with lower cost than weed-free till maturity treatment.

Thus pre-emergence application of anilofos + 2,4-DEE (0.3 + 0.5 kg a.i./ha) supplemented either with 1 hand-weeding at 40 days or 2,4-DEE as post-emergence application and or anilofos (0.4 kg a.i./ha) + 1 hand-weeding at 40 days may be used as an effective and economically viable weed-management practice for direct-sown rice and succeeding lentil under rainfed lowland situation.

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