

Effect of weed management practices on productivity, nutrient depletion by weeds and uptake by transplanted rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted in a randomized block design during the rainy (*khari*) season of 2012 at Pantnagar, Uttarakhand, to evaluate the effect of different weed-control treatments on productivity, nutrient depletion by weeds as well as uptake by rice (*Oryza sativa* L.). Weed-management practices significantly influenced yield, nutrient uptake by rice and depletion by weeds. Pre-emergence application of pretilachlor 750 g/ha + no irrigation up to 1 week followed by (fb) early post-emergence application of bispyribac-Na (20 g/ha) provided broad-spectrum weed-control, resulting in significant reduction in N, P and K removal by the weeds. This treatment also registered the maximum total N, P and K uptake by rice (116.3, 35.6, and 108.7 kg/ha) and significantly higher grain (5.73 t/ha) as well as straw (8.39 t/ha) yields over pre-emergence application of pretilachlor, pretilachlor + no irrigation up to 1 week and cono weeding fb 1 hand-weeding, but remained at par with the other treatments. Application of penoxsulam at both the doses (22.5 and 25 g/ha) was at par with bispyribac-Na 20 g/ha in terms of grain and straw yields.

Key words : Herbicides, Nutrient uptake, Transplanted rice, Weeds, Yield

Rice is one of the most important and widely cultivated crops in the world. About 20% of the world's total rice is produced in India (Singh *et al.*, 2012). India is the second largest producer of rice where it is cultivated in an area of 43.9 million ha, with a production of 106.5 million tonnes and an average productivity of 2.4 t/ha during 2013–14 (Economic Survey 2014–15). Weeds are one of the major yield-limiting biotic constraints to rice production. Transplanted rice suffers from heavy infestation by heterogeneous or diverse types of weed flora, consisting of grassy, broad-leaf weeds and sedges causing yield reduction up to 50% (Halder and Patra, 2007). Crop yield losses due to weeds mainly depend on their intensity as well as type of weed flora. They usually grow faster and absorb the avail-

able nutrients earlier, faster and in large quantities, resulting in deprivation of nutrients for the crop. Weeds removed nutrients (N, P and K) 8 times higher under direct-seeded rice compared to transplanted rice (Singh *et al.*, 2002). Severe infestation of weeds in rice suppressed the plant height, increased tiller mortality, decreased shoot and grain production. Weeds compete with crop for all critical growth factors, viz. nutrient, space, light, soil moisture resulting in considerable yield losses. Several weed-management approaches, viz. manual, mechanical, cultural and chemical methods are adopted for controlling weeds in transplanted rice. Though manual weeding is very popular and effective but expensive, tedious and time-consuming, chemical control is effective, requires less time and labour. Continuous application of same herbicide leads to shift in weed flora and development of resistance to herbicides (Singh *et al.*, 2013). However, due to variable growth habit and life-cycles of weeds, no single method can effectively control weeds in all situations. The complexity of these situations has resulted in need to the development of integrated weed-management strategies for effective management of diversified weed flora in transplanted rice. In this context, the present investigation was undertaken to evaluate the effect of different weed-

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management practices on productivity, nutrient depletion by weeds and uptake by transplanted rice.

The field study was carried out during the rainy (*kharij*) season of 2012 at the Norman E. Borlaug Crop Research Centre of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (29° N, 79.3° E and 243.8 m above mean sea-level) Uttarakhand, in *tarai* belt of Shivalik range in foothills of Himalayas. The soil of the experimental site was silty loam in texture with pH 7.3, high in organic carbon (0.86%), low in available nitrogen (226.2 kg/ha), but medium in available phosphorus (22.8 kg/ha) and potassium (145.4 kg/ha). The experiment was laid out in a randomized block design with 3 replications. The treatments comprised post-emergence application of penoxsulam at 20, 22.5 and 25 g/ha denoted as T₁, T₂ and T₃, respectively; early post-emergence application of bispyribac-Na 20 g/ha (T₄); pre-emergence application of pretilachlor 750 g/ha (T₅); pre-emergence application of pretilachlor 750 g/ha fb 1 hand-weeding (HW) 45 days after transplanting (DAT) (T₆); post-emergence application of penoxsulam 20 g/ha fb 1 HW at 45 DAT (T₇); pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week (T₈); pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T₉); conoweeding at 15 DAT fb 1 HW at 45 DAT (T₁₀); twice HW at 20 and 40 DAT (T₁₁); and weedy check (T₁₂). To all the treatments, irrigation was applied to saturation level of water except pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week (T₈) and pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T₉) to provide the aerobic situation for emergence of weeds in experimental plots. In both these treatments, irrigation was withheld up to initial 1 week after transplanting. Thereafter, irrigation was common to all the plots. Pre-emergence application of pretilachlor was done at 3 DAT, while early post and post-emergence application of bispyribac-Na and penoxsulam were applied at 14 and 20 DAT respectively. Weedy check plots were kept undisturbed for the entire growing period of crop. Twenty-five days old seedlings of tested rice variety 'Sarjoo 52' was transplanted using 2 seedlings per hill on 6 July 2012 at 20 cm × 10 cm spacing. All the herbicides were applied by knap-sack sprayer fitted with a flat-fan nozzle using a spray volume of 500 L water/ha by keeping a thin film of water in the field. Application of nutrients was done uniformly to all the experimental plots (5 m × 3 m) as per the recommendation (120 : 60 : 40 kg/ha of N, P and K respectively) through, NPK mixture (12:32:16) and murate of potash. Half dose of N and full P₂O₅ and K₂O were applied as basal before seedling trans-

planting and balance N were top-dressed in 2 equal splits—one-fourth at active tillering (30–35 DAT) and the remaining one-fourth at panicle-initiation (60–65 DAT) stage of the crop. For preventing occurrence of *khaira* disease (zinc deficiency), basal dressing of Zn was done through zinc sulphate (20 kg/ha). All other cultural practices were followed as per the recommended package of practices. Observations on nutrient removal by weeds and uptake by rice crop were recorded along with yield. Nitrogen, phosphorus and potassium content were analyzed in rice crop at harvesting and in total weeds at 90 DAT by adopting modified micro-kjeldahl method for estimation of nitrogen, vanado molybdo phosphoric acid method for phosphorus and flame-photometric method for potassium as described by Jackson (1973). The nutrient uptake (kg/ha) was calculated by using their nitrogen, phosphorus and potassium concentration values and dry matter of crop plant and weeds on hectare basis. Nutrient uptake was calculated as:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient concentration (\%)} \times \text{Weight of dry matter (kg/ha)}}{(100)}$$

The yield and yield parameters were recorded at harvesting. The crop was harvested manually with the help of sickle at height of 10–15 cm above ground level on 3 November 2012. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures and comparison of treatment means was made by critical difference (CD) at 0.05 probability.

The predominant weed flora associated with the experimental field were *Echinochloa colona*, *E. crus-galli*, *Leptochloa chinensis*, *Ischaemum rugosum* among grasses and *Ammania baccifera*, *Alternanthera sessilis* and *Ceasulia axillaris* among broad-leaf weeds, and *Cyperus difformis* was the only species found among the sedges. The grasses constituted 46.4%, broad-leaf weeds 42.2% and sedges 11.5% of the total weed population at 60 DAT under weedy conditions.

Depletion of nutrients from soil is function of dry weight and nutrient content in weed plants. Weeds usually grow faster than crop plants and thus absorb the available nutrients earlier, resulting in lack of nutrient for growth of crop plants (Sharma *et al.*, 2007). Different weed-management practices had a profound influence on the nutrient removal by weeds at 90 DAT. All the weed-control treatments significantly reduced N, P and K depletion by weeds compared with the weedy check (Table 1). The efficiency of the weed-control treatment and the nutrient removal by weeds was negative to each other. Weedy check (T₁₂) registered the maximum nutrients (N, P and K) removal by weeds over rest of the treatments. Among the treatments, pretilachlor 750 g/ha applied as pre-emergence with no irrigation up to 1 week fb early post-emergence

application of bispyribac-Na 20 g/ha (T₉) provided broad-spectrum weed control resulting in significant reduction in removal of N, P and K by the weeds which was closely fb hand-weeding twice at 20 and 40 DAT (T₁₁) and early post-emergence application of bispyribac-Na 20 g/ha (T₄). However, among herbicides alone and integration with other weed-management approaches, maximum N, P and K removal was noticed with conoweeding (15 DAT) fb 1 HW at 45 DAT (T₁₀) fb pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week (T₈). The highest depletion of N, P and K by weeds in weedy check treatment is attributed to uncontrolled weed growth which resulted in increased dry-matter production of weeds. Presumably, the excessive weed growth resulted in higher crop-weed competition for growth factors and thus, prevented rice plants from absorbing adequate amount of nutrients in weedy plot. Jacob and Syriac (2005) also reported similar results. Among the weed-control treatments, the lowest removal of N, P and K by weeds with pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T₉) might be ascribed to the lower weed density and dry-matter accumulation, aiding in reduced quantum of N, P and K removal by weeds as a result of sequential application of pretilachlor applied as pre-emergence fb early post-emergence application of bispyribac-Na.

Nutrient uptake being a function of dry-matter production and partly due to increase in its concentration. Significant variations were observed in the nutrient (N, P and K) uptake by the crop at harvesting among different weed-control treatments (Table 1). The highest nitrogen uptake by grain as well as straw was recorded with pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T₉) which remained at par with early post-emergence application of bispyribac-Na 20 g/ha alone (T₄) and twice hand-weeding at 20 and 40 DAT (T₁₁), while the lowest was obtained with weedy check (T₁₂). Phosphorus uptake in rice grain was the highest with pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb bispyribac-Na 20 g/ha applied as early post-emergence (T₉), while in straw it was maximum with penoxsulam 25 g/ha (T₃) applied as post-emergence. The lowest phosphorus uptake in both grain and straw of rice was observed under weedy check (T₁₂). Application of pretilachlor 750 g/ha

Table 1. Effect of weed-management practices on nutrient uptake by weeds and rice crop and grain and straw yields

Treatment	Application stage (DAT)	Dose (g/ha)	Nutrient depletion (kg/ha) by weeds (90 DAT)			Nutrient uptake (kg/ha) by rice crop (at harvesting)						Yield (t/ha)		Grain: straw ratio			
			N	P	K	N		P		K		Grain	Straw				
						Grain	Straw	Grain	Straw	Grain	Straw				Total	Total	
T ₁ Penoxsulam (PoE)	20	20.0	5.9	1.4	3.2	58.1	33.1	91.2	20.9	8.7	29.6	15.7	74.8	90.5	4.89	7.24	0.68
T ₂ Penoxsulam (PoE)	20	22.5	4.6	1.1	2.4	62.1	35.0	97.1	20.3	9.9	30.2	17.5	78.1	95.6	5.16	7.45	0.70
T ₃ Penoxsulam (PoE)	20	25.0	4.2	0.9	2.4	64.0	36.9	100.9	18.4	15.2	33.6	19.3	81.5	100.8	5.26	7.50	0.71
T ₄ Bispyribac-Na (EPoE)	14	20.0	2.9	0.7	1.4	72.0	40.6	112.6	19.1	12.6	31.7	21.9	84.1	106.0	5.63	7.86	0.72
T ₅ Pretilachlor (PE)	3	750	7.6	1.6	3.9	59.5	32.5	92.0	17.6	12.9	30.5	19.2	67.1	86.3	4.84	6.82	0.71
T ₆ Pretilachlor fb 1 HW	3 fb 45	750	3.4	0.8	1.8	67.9	33.0	100.9	17.6	12.8	30.4	20.7	84.3	105.0	5.39	7.51	0.72
T ₇ Penoxsulam fb 1 HW	20 fb 45	22.5	4.2	1.0	2.3	65.0	37.5	102.5	15.9	12.8	28.7	16.7	83.6	100.3	5.36	7.56	0.72
T ₈ Pretilachlor + no irrigation up to 1 week	3	750	8.5	2.0	4.0	58.4	35.3	93.7	13.6	9.1	22.7	16.5	62.6	79.1	4.64	6.50	0.72
T ₉ Pretilachlor + no irrigation up to 1 week fb bispyribac-Na	3 fb 14	750 fb 20.0	0.8	0.2	0.4	74.9	41.4	116.3	23.3	12.3	35.6	24.3	84.4	108.7	5.73	8.39	0.69
T ₁₀ Cono weeding fb 1 hw	15 fb 45	-	10.9	2.7	5.9	55.4	35.8	91.2	13.9	12.2	26.1	19.7	67.0	86.7	4.48	6.74	0.66
T ₁₁ Twice HW	20 and 40	-	1.9	0.4	1.0	70.3	38.3	108.6	21.2	11.4	32.6	17.8	85.0	102.8	5.63	7.76	0.73
T ₁₂ Weedy check	-	-	19.7	4.9	10.5	24.7	16.0	40.7	5.9	4.6	10.4	6.1	36.1	42.2	2.29	3.96	0.59
SEm±	-	-	0.9	0.2	0.5	2.9	1.9	3.9	0.7	0.7	1.0	0.8	4.1	4.3	0.24	0.41	0.04
CD (P=0.05)	-	-	2.7	0.6	1.4	8.4	5.4	11.4	1.9	2.0	3.0	2.4	12.1	12.7	0.70	1.21	NS

PE, Pre-emergence; PoE, post-emergence; EPoE, early post-emergence; HW, hand-weeding; DAT, days after transplanting; fb, followed by; NS, non-significant

with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T_9) recorded the highest potassium uptake in rice grain, while in straw it was obtained with twice hand-weeding at 20 and 40 DAT (T_{11}). Weedy check (T_{12}) recorded the lowest potassium uptake in both grain and straw of rice crop. Among alone application of herbicides, the highest potassium uptake by grain and straw was registered with bispyribac-Na 20 g/ha applied as early post-emergence (T_4). Data revealed that the potassium uptake was higher in straw than grain. The increase in potassium uptake in straw thus strengthens the stalk of rice plant providing resistance against attack of insect-pests and lodging. Among different weed-control treatments, weedy check (T_{12}) recorded the lowest uptake of total N, P and K by crop, while the highest was obtained with pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb bispyribac-Na 20 g/ha applied as early post-emergence (T_9). This might be attributed to lower weed population and dry weight, which helped the crop to grow in weed-free environment and absorb more nutrients from the soil and due to active and massive root-system which might have caused increased uptake of nutrients. Several studies showed that the reduction in weed population and weed dry weight caused increased uptake of nutrients by crop.

Among different weed-control treatments, sequential application of pretilachlor 750 g/ha applied as pre-emergence with no irrigation up to 1 week fb bispyribac-Na 20 g/ha applied as early post-emergence (T_9) recorded significantly higher grain as well as straw yields over pretilachlor 750 g/ha applied as pre-emergence (T_5), pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week (T_8) and conoweeding (15 DAT) fb 1 HW at 45 DAT (T_{10}) but remained at par with rest of the treatments (Table 1). The lowest grain/straw: ratio (0.59) was recorded with weedy check, while the highest was obtained with twice hand-weeding at 20 and 40 DAT (T_{11}). The higher grain yield with pretilachlor 750 g/ha applied as pre-emergence with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha (T_9) might be attributed to season long effective control of diverse weed flora due to sequential application of pre followed by post-emergence herbicide which resulted in more number of panicles/m² and grains/panicle. These results corroborate with the findings of Uma *et al.* (2014). The higher straw yield with this treatment might be attributed to more plant height and dry-matter accumulation due to reduced crop-weed competition. Among the different doses of penoxsulam, post-emergence application of penoxsulam 25 g/ha (T_3) recorded the higher grain yield followed by its lower dose 22.5 g/ha (T_2) owing to enhanced number of panicles/m² and grains/panicle. These

findings are in line with the results of Khare *et al.* (2014). Post-emergence application of penoxsulam 22.5 g/ha (T_2) and 25 g/ha (T_3) gave at par grain and straw yields with bispyribac-Na applied as early post-emergence (T_4). Similar results was also reported by Nath *et al.* (2014). Integrated application of pretilachlor (T_6) or penoxsulam (T_7) supplemented with 1 hand-weeding (45 DAT) did not reach the grain yield up to significant level over their sole application.

It was concluded that pre-emergence application of pretilachlor 750 g/ha with no irrigation up to 1 week fb early post-emergence application of bispyribac-Na 20 g/ha may be followed for attaining higher productivity, nutrient uptake by rice crop and lower depletion by weeds in transplanted rice.

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