Indian Journal of Weed Science **45**(2): 109–112, 2013

Efficacy of herbicides on wheat and their terminal residues in soil, grain and straw

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Received: 5 March 2013; Revised: 26 May 2013

ABSTRACT

A field experiment was conducted during *Rabi* season of 2006-07 and 2007-08 at Gwalior (M.P.) to evaluate the effect of herbicides on weed control and yield of wheat (*Triticum aestivatum* L.) and residues of herbicides in post harvest soil, grain and straw of wheat. Ten treatments consisting of post emergence application of two doses of isoproturon (1.0 and 2.0 kg/ha), clodinafop- propargyl (60 and 120 g/ha), fenoxaprop -p-ethyl (60 and 120 g/ha) and sulfosulfuron (25 and 50 g/ha) along with two hand weeding and weedy control were evaluated in randomized block design with four replications. Samples of post harvest soil, grain and straw of wheat with higher dose of herbicides were analysed for herbicide residues by HPLC using PDA detector. Lowest weed population and weed dry weight at 60 days after sowing was recorded in isoproturon at both concentrations while lowest weed biomass at harvest and weed control efficiency was recorded in sulfosulfuron 25 g/ha followed by two hand weeding. Highest wheat yield (5.4 t/ha) was recorded in two hand weeding which was at par with sulfosulfuron 50 g/ha. clodinafop 60 g/ha, sulfosulfuron 25 g/ha and isoproturon 2.0 kg/ha. A reduction of 55.4% in wheat yield in weedy check was observed as compared to two hand weeding. A residue of 0.006, 0.041 and 0.022 µg/g isoproturon was in post harvest soil, wheat grain and straw while residues of 0.021 and 0.096 (µg g/g) clodinafop was present in soil and grain at higher level of application.

Key words: Clodinafop, Fenoxaprop-p-ethyl, Herbicide residue, Isoproturon, Sulfosulfuron, Weed dry weight, Weed population

Wheat (*Triticum aestivatum* L.) is the most important winter cereal crop of India. Isoproturon was recommended for weed control in wheat during 1980-81 and it became popular among the farmers. However, with the sole use of isoproturon continuously for a longer period, resistance in *Phalaris minor* to this herbicide was developed in Haryana (Malik and Singh 1993) and Punjab (Walia *et al.* 1997). Therefore, now a days, clodinafop, fenoxaprop-p-ethyl and sulfosulfuron are being recommended for efficient weed control in wheat (Chhonkar and Malik 2002) and are being used by farmers on large scale and are required in low doses. At the recommended dose of herbicide application, generally the problem does not arise and it selectively kills the weeds. But when the dose is more than recommended rates or due to indiscriminate use and improper calibration and method of application, there is possibility of residual hazards in soil and crop produced and can be harmful for human and animals. Keeping these in view, the study was under taken to assess the efficacy of these herbicides on weeds in wheat and to find out the residues of these herbicides in post-harvest soil, grain and straw of wheat.

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MATERIALS AND METHODS

The field experiment was conducted during *Rabi* season of 2006-07 and 2007-08 at Research farm, College of Agriculture, Gwalior to evaluate the effect of herbicides on weed control and wheat productivity and residues of herbicides in post harvest soil, grain and straw of wheat. The experimental soil was sandy clay loam with 55.2% sand, 19.4% silt, 25.4% clay and 0.54% organic carbon having pH 7.2. Ten treatments consisting of isoproturon (1.0 and 2.0 kg/ha), clodinafop- propargyl (60 and 120 g/ha), fenoxaprop-p-ethyl (60 and 120 g/ha), and sulfosulfuron (25 and 50 g/ha) along with two hand weeding (30 and 60 days after sowing) and weedy control were evaluated in randomized block design with four replications. The wheat crop variety MP 4010 was sown in rows 22.5cm apart on 19 and 17 November 2006 and 2007, respectively with recommended doses of nutrients (120 kg N, 26.2 kg P and 33.3 kg K/ha in both the years) applied to all the plots. The herbicides were sprayed as post emer-

gence 30 days after sowing (DAS) using a spray volume of 500 L/ha with a knapsack sprayer fitted with flat fan nozzle. Total rainfall received during crop season were 57.5 and 1.2 mm in first and second year respectively. The data on weed count and weed dry weight were recorded 60 DAS from an area enclosed in the quadrate of 0.25 m^2 at two places under each plot. Data on weed population were subjected to logarithmic transformation. Wheat yield and weed biomass were recorded at harvest. Soil, grain and straw samples of wheat were collected at the time of harvest and only samples with double the recommended herbicide were taken for quantitative residue analysis of herbicides. The soil, grain and straw samples were extracted for the herbicides as per the methods given by Sondhia (2006) and analyzed on a Shimadzu high performance liquid chromatography equipped with diode array detector at 206, 230, 235 and 215 nm and the retention time found was 4.6 min, 2.09 min, 2.15 min and 2.18 min for isoproturon, sulfosulforon, fenoxaprop and clodinafop respectively. Acetonitrile : water (70:30) was used as mobile phase with flow rate of 1 ml/min and detection limit 0.001 µg/g. The analysis was carried out in Residue Laboratory of Directorate of Weed Science Research, Jabalpur.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was dominated by infestation of broad leaved weeds like *Spergula arvensis, Anagallis arvensis, Chenopodium album, Melilotus indica* and *Convolvulus arvensis* ; grasses like *Phalaris minor* and sedges like *Cyperus rotundus*. The maximum mean weed population of two years was recorded in weedy check followed by fenoxaprop 240 g/ha and fenoxaprop 120 g/ha (Table 1). The lowest weed density was recorded in isoproturon 1.0 kg/ha which was at par with isoproturon 2.0 kg/ha, two hand weeding , clodinafop 60 and 120 g/ha and was found to be significantly lower than rest of the treatments. Weed dry weight reflects the growth potential of the weeds and its competitive ability with the crop plants. Weedy check recorded the highest weed dry weight while lowest weed dry weight was recorded in isoproturon 2.0 kg/ha followed by isoproturon 1.0 kg/ha, sulfosulfuron 50 g/ha and sulfosulfuron 25 g/ha. Dry weight of weeds under all herbicidal treatments and two hand weeding were at par to each other except fenoxaprop at both doses which was significantly higher than all weed control treatments. Although in most of the treatments, weed population and dry weight of weeds were recorded lower in the recommonded doses of herbicides as compared to double the recommonded, the differences were non significant. At harvest weed biomass was recorded lowest in sulfosulfuron 25 g/ha followed by two hand weeding, sulfosulfuron 50 g/ha, isoproturon 2.0 kg/ha and isoproturon 1.0 kg/ha (Table 2). Similar trend was observed for weed control efficiency with highest value recorded by sulfosulfuron 25 g/ha (95.2%) followed by two hand weeding (94.0%). It indicates that sulfosulfuron checks the growth of weeds more efficiently beyond 60 DAS as compared to isoproturon and other herbicides applied. Verma *et al.* (2007) found better weed control at 90 and 120 DAS by sulfosulfuron followed by fenoxaprop 100 g/ha and isoproturon 1.0 kg/ha. In our study fenoxaprop @ 120 and 240 g/ha was not effective to control weeds as it resulted in significantly highest weed count and weed dry weight at 60 DAS and weed biomass at harvest.

Effect on crop

Maximum mean grain yield of two year was recorded in two hand weeding (5.42 t/ha) treatment. Application of

Table 1. Effect of herbicidal treatment on population and dry weight of weeds in wheat

Treatment	Weed population/m^2*			Dry weight (g/m^2)		
	2006-07	2007-08	Mean	2006-07	2007-08	Mean
Isoproturon 1.0 kg/ha	2.79 (16.2)	2.74 (15.0)	2.75 (15.6)	37.5	24.1	30.8
Isoproturon 2.0 kg/ha	3.16 (23.0)	2.42 (12.0)	2.81 (17.5)	9.4	13.5	11.5
Clodinafop 60 g/ha	3.75 (44.2)	3.36 (30.5)	3.60 (37.3)	33.2	48.5	40.8
Clodinafop 120 g/ha	3.92 (51.7)	3.14 (23.0)	3.54 (37.3)	51.2	41.8	46.5
Fenoxaprop 120 g/ha	3.63 (44.5)	4.74 (127.5)	4.32 (86.0)	81.5	204.3	142.9
Fenoxaprop 240 g/ha	3.91 (51.0)	4.93 (150.5)	4.47 (100.7)	114.5	197.1	155.8
Sulfosulfuron 25g/ha	3.86 (47.0)	3.85 (70.0)	4.05 (58.5)	30.5	45.8	38.1
Sulfosulfuron 50 g/ha	3.51 (33.5)	3.87 (68.5)	3.87 (52.0)	45.3	31.7	38.5
Weedy check	5.19 (180.7)	5.73 (291.2)	5.44 (235.9)	204.5	373.8	289.2
Weed Free (Twice)	3.80 (48.0)	2.00 (7.2)	2.92 (27.6)	109.0	8.7	58.8
LSD (P=0.05)	0.56	0.80	0.76	69.9	59.5	82.1

*Data subjected to Logarithmic transformation. Figures in the parentheses are the original values

Table 2. Effect of different treatments on seed yield, weed biomass, weed control efficiency, net returns and B :C ratio in wheat

Treatment	Seed yield (t/ha)			Weed biomass at harvest (kg/ha)			Mean of two years		
	2006-07	2007-08	Mean	2006-07	2007-08	Mean	WCE (%)	Net returns (x10^3 ₹/ha)	BCR
Isoproturon 1.0 kg/ha (POE)	4.29	3.79	4.04	117	173	145	89.0	36.97	3.10
Isoproturon 1.0 kg/ha (POE)	4.95	4.19	4.57	110	163	136	89.7	43.56	3.40
Clodinafop 60 g/ha (POE)	5.50	3.89	4.70	83	315	199	84.9	43.53	3.55
Clodinafop 120 g/ha (POE)	3.55	4.14	3.85	58	272	165	87.5	33.19	2.77
Fenoxaprop 120 g/ha (POE)	2.72	3.46	3.09	418	986	702	46.9	23.71	2.32
Fenoxaprop 240 g/ha (POE)	2.26	2.74	2.50	517	1271	894	32.4	14.82	1.78
Sulfosulfuron 25 g/ha (POE)	5.31	3.98	4.65	69	58	63	95.2	45.02	3.54
Sulfosulfuron 50 g/ha (POE)	5.76	4.42	5.09	113	74	93	93.0	50.29	3.72
Weedy check	2.38	2.46	2.42	775	1871	1323	-	15.64	1.92
Weed free	5.63	5.22	5.42	137	22	79	94.0	52.03	3.45
LSD (P=0.05)	0.92	1.04	1.04	1111	403	798	-	-	-

sulfosulfuron 50 g/ha (5.09 t/ha), clodinafop 60 g/ha (4.6 t/ha), sulfosulfuron 25 g/ ha (4.6 t/ha) and IPU 2.0 kg/ha (4.5 t/ha) were at par with two hand weeding treatment in respect of grain yield and they were superior to all other treatments during both years. Better performance of these treatments in terms of yield could be owing to better control of complex weed flora tilting the crop weed competition in favour of the crop. Higher weed population and weed dry weight showed reduction of 55.42% grain yield (Table 2) in weedy check compared to hand weeding twice. In both the years fenoxaprop showed phytotoxicity as yellowing of plants at both the doses which was recovered after 70-80 DAS. Fenoxaprop at both doses failed to increase the seed yield significantly over weedy check possibly due to its lower WCE and phytotoxicity. Shukla and Mishra (2006) also found highest wheat grain yield in sulfosulfuron (25 g/ha) followed by clodinafop (60 g/ha), isoproturon (1.0 kg/ha) and fenoxaprop (90 g/ha) under bed planted late sown wheat.

Economics

The economic analysis based on mean of two years (Table 2)indicated that maximum net return was obtained with two hand weeding (₹52,035), followed by sulfosulfuron 50g/ha (₹ 50,287) and sulfosulfuron 25g/ha (₹ 45,019) while highest benefit cost ratio (BCR) was obtained with sulfosulfuron 50 g/ha (3.72) followed by clodinafop 60 g/ha (3.55), sulfosulfuron 25 g/ha (3.54) and two hand weeding (3.45).

Herbicide residues

The analysis of terminal residue of herbicides in post harvest soil (Table 3) indicated that residue of 0.006 and 0.021 µg/g isoproturon and clodinofop respectively were detected in post harvest soil whereas no residues of fenoxaprop and sulfosulfuron were detected in soil. Similarly in wheat grain, isoproturon and clodinofop residues were present at the level of 0.041 and 0.096 µg/g, which were below the MRL (0.05 mg/kg for isoproturon and 0.1 mg/kg for clodinofop). In wheat grain sulfosulfuron residues were below detectable limit. In straw only isoproturon residue could be detected to the level of 0.022 µg/g. Sondhia (2006) reported isoproturon and fenoxaprop residues in post harvest soil, grains and straw of wheat, while residues of sulfosulfuron were detected in wheat grain and straw only. Sulfosulfuron residues were not found in wheat grains, straw and subsequent vegetables in natural ecosystem as well as in model ecosystem at 25 and 50 g/ ha in wheat crop (Ramesh and Maheshwari, 2003; Sondhia *et al*. 2007). Chandi *et al.* (2005) also revealed that grains and straw of Durum wheat contained the residues of isoproturon and sulfosulfuron below the detectable limits. The residues of clodinofop (60-120 g/ha) were not detected in wheat grain and soil at harvest, however, 0.0089 ppm residues were detected in wheat grains at 240 g/ha (Sondhia and Mishra 2005).

Table 3. Residues of herbicides (µg/g) in post-harvest soil, grain and straw of wheat crop

Herbicide	Soil	Grain	Straw
IPU 2.0 kg/ha	0.006	0.041	0.022
Clodinafop 120 g/ha	0.021	0.096	BDL
Fenoxaprop 240 g/ha	BDL	ND	ND
Sulfosulfuron 50 g/ha	BDL	BDL	BDL

BDL – Below detectable limit (0.001 µg/g); ND – Not done

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