

Carry-over effect of imazethapyr applied to soybean (*Glycine max*) on wheat (*Triticum aestivum*) + pea (*Pisum sativum*) cropping system

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ABSTRACT

A field experiment was conducted during 1990–91 and 1991–92 to study the residual effect of imazethapyr applied to soybean [*Glycine max* (L.) Merr.] at different doses and times on wheat (*Triticum aestivum* L. emend. Fiori & Paol.) and pea (*Pisum sativum* L. sensu lato) cropping system. Residues of imazethapyr 200 g/ha (pre-emergence) reduced the population and dry matter of weeds in wheat + pea system significantly. The combined effect of residues of imazethapyr 200 g/ha and of hand-weeding and isoproturon applied to wheat + pea resulted in weed-control efficiency of 72.1–81.6%. The residues of imazethapyr at different doses did not show phytotoxic effect on the growth, development and yield of wheat and pea crops during both the years. The direct effect of isoproturon and hand-weeding twice in wheat + pea cropping system being statistically at par increased the growth of both the crops and grain yield of wheat significantly over the unweeded check. But the seed yield of pea and wheat-equivalent yield were significantly higher with hand-weeding twice over isoproturon.

Herbicides differ in their persistence under different environmental conditions. It is essential to identify herbicides of longer persistence with residues sufficient for effective control of weeds in the succeeding crop without any phytotoxicity to the crop. Imazethapyr, a new imidizolinone herbicide having longer persistence (Johnson and Talbert, 1989) and broad spectrum of weed control (Dobson *et al.*, 1988), has been introduced in India. As it is a new herbicide, very little information is available regarding its persistence and residual effect on weeds and crops in a rotation. Gunsolus *et al.* (1986) reported carry-over effect of it on maize and oat from the previous season's imazethapyr (0.14 and 0.28 kg/ha) application in acidic soils. Therefore present investigation was undertaken to study the

residual effect of imazethapyr applied to soybean [*Glycine max* (L.) Merr.] on growth and development of subsequent wheat (*Triticum aestivum* L. emend. Fiori & Paol.) + pea (*Pisum sativum* L. sensu lato) cropping system and weeds associated with these crops.

MATERIALS AND METHODS

The field study was carried out during 1990–91 and 1991–92 at Palampur. The soil of the experimental field was silty clay-loam, with acidic (pH 5.8) in reaction, medium in available phosphorus (17.9 kg/ha), high in potassium (306.5 kg/ha) and low in available nitrogen status (206 kg/ha). The experiment with soybean consisted of 14 treatment combinations of 4 doses of imazethapyr (50, 100, 150 and 200 g/ha) and

3 times of application (pre-plant incorporation, pre-emergence and early post-emergence) with hand-weeding twice and unweeded as checks in randomized block design with 3 replications. The residual effect of treatments was studied in split-plot design by sowing wheat + pea (3 : 1) in the same main plots without disturbing the lay-out. Wheat variety 'Sonalika and pea variety 'HPCC 64' were sown on 12 November 1990 and 9 November 1991 during first and second years respectively. Each main plot was subdivided into 3 subplots to which 3 weed-control treatments, viz. unweeded check, hand-weeding twice and isoproturon 1.0 kg/ha, were applied. The range of weekly maximum, minimum and mean temperature during growing season was respectively 11.1–31.3°C, 2.0–18.5°C and 6.6–24.9°C during 1990–91 and 10.6–29.6°C, 2.6–17.8°C and 6.6–23.6°C respectively during 1991–92. The total rainfall during growing season was 483 and 689 mm during first and second years of study. The efficiency of treatments was assessed recording the dry matter of weeds and weed count by throwing 50 cm x 50 cm quadrat in each plot at random. The residual effect on wheat and pea was estimated by recording their growth, development and yield.

RESULTS AND DISCUSSION

Effect of treatment on weeds

Treatments applied in soybean had significant effect on weeds of the succeeding crop of wheat + pea during both the years. Residues of imazethapyr 200 g/ha (at all the times of application) increased the weed-control efficiency by decreasing the total weed count and dry matter significantly but was statistically at par with imazethapyr 150 g/ha in reducing the dry matter of weeds

during second year (Table 1). The residues of lower doses of 50–100 g/ha being statistically at par were least effective and were at par with unweeded check and hand-weeding twice in reducing the weed count and dry-matter accumulation. However, during the first year, residues of 100 g/ha imazethapyr was superior to 50 g/ha in reducing the dry matter of weeds. Although the time of application of imazethapyr in soybean did not influence significantly the weed count and dry matter of weeds, its residues of pre-plant incorporation were relatively more effective probably due to lesser loss of herbicide through leaching, volatilization and photo-decomposition in this method of application.

Under the unweeded check condition, residues of imazethapyr 200 g/ha controlled the weeds, with weed control efficiency of 4–7% (Table 2). But it along with hand-weeding twice and isoproturon residues of imazethapyr 200 g/ha increased the weed-control efficiency by 3.1–4.2% over the direct effect of hand-weeding and isoproturon. The combined effect of residues of imazethapyr 200 g/ha and of hand-weeding and isoproturon applied to wheat + pea resulted in weed-control efficiency of 72.1–81.6%. The residues of lower doses of imazethapyr did not control the weeds of wheat + pea cropping system significantly.

The hand-weeding twice and isoproturon applied to wheat + pea crops reduced the total weed population and dry-matter accumulation during both the years. However, isoproturon was significantly superior to hand-weeding during the first year, whereas during the second year hand-weeding was superior to isoproturon.

Effect of treatments on wheat

The plant height and dry matter of wheat

Table 1. Residual effect of imazethapyr and direct effect of weed-control treatments applied to wheat + pea on total weed count (No./m²) and total dry matter of weed (g/m²)

Treatment	Dose (g/ha)	Weed count		Weed-dry matter	
		1990-91	1991-92	1990-91	1991-92
<i>Residual effect</i>					
Imazethapyr [†]	50	14.14 (221.1)	17.24 (339.9)	264.11	313.78
Imazethapyr [‡]	50	14.71 (239.2)	16.78 (328.0)	266.22	315.44
Imazethapyr ^{§§}	50	14.54 (239.1)	17.13 (328.4)	266.27	315.83
Imazethapyr [†]	100	13.91 (216.1)	17.18 (336.9)	254.89	306.47
Imazethapyr [‡]	100	14.49 (231.1)	16.29 (312.7)	258.56	308.56
Imazethapyr ^{§§}	100	13.80 (209.7)	16.73 (318.0)	256.44	310.83
Imazethapyr [†]	150	14.07 (200.0)	16.56 (318.3)	246.78	302.46
Imazethapyr [‡]	150	13.34 (196.7)	15.93 (301.0)	247.23	302.87
Imazethapyr ^{§§}	150	13.29 (195.0)	15.97 (298.9)	247.61	304.79
Imazethapyr [†]	200	12.82 (182.8)	15.77 (283.6)	240.67	297.11
Imazethapyr [‡]	200	12.58 (175.7)	15.02 (273.4)	240.33	297.11
Imazethapyr ^{§§}	200	12.49 (175.8)	15.02 (267.2)	239.08	296.71
Hand-weeding	25, 45 days*	15.53 (239.1)	16.98 (328.6)	263.89	314.37
Unweeded		14.54 (233.3)	17.13 (339.7)	265.33	315.28
CD (P = 0.05)		0.71	0.67	5.07	8.57
<i>Direct effect</i>					
<i>Wheat + pea treatment</i>					
Unweeded		19.48 (381.2)	25.61 (654.7)	500.09	588.06
Hand-weeding	30, 60 days*	13.68 (176.9)	11.51 (133.5)	155.11	165.26
Isoproturon 1.0/1.5	35 days*	8.60 (75.0)	12.11 (149.0)	106.88	168.38
CD (P = 0.05)		0.35	0.35	2.55	3.71

Figures in parentheses are means of original values

[†]Preplant incorporation; [‡]pre-emergence; ^{§§}post-emergence

*Days, Days after sowing

Table 2. Residual effect of imazethapyr and direct effect of treatments applied to wheat + pea on weed-control efficiency in wheat + pea cropping system

Treatment	Dose (q/ha)	1990-91			1991-92		
		UC	HW	Isop.	UC	HW	Isop.
Imazethapyr [†]	50	1.2	68.0	77.4	-0.2	72.0	70.9
Imazethapyr ^ψ	50	0.3	67.4	77.7	0.6	70.8	70.5
Imazethapyr ^{ψψ}	50	-0.1	68.0	77.5	-0.7	71.2	71.2
Imazethapyr [†]	100	3.6	69.4	79.0	2.1	72.5	71.8
Imazethapyr ^ψ	100	2.1	68.6	79.2	2.2	71.6	71.6
Imazethapyr ^{ψψ}	100	2.7	70.0	78.4	1.0	71.7	71.6
Imazethapyr [†]	150	5.0	71.4	80.3	3.1	73.0	72.4
Imazethapyr ^ψ	150	4.6	70.9	80.9	2.6	72.9	72.5
Imazethapyr ^{ψψ}	150	4.7	71.6	80.0	1.9	72.8	72.6
Imazethapyr [†]	200	6.8	72.1	81.3	4.0	74.2	73.2
Imazethapyr ^ψ	200	6.5	72.4	81.6	4.0	74.2	73.0
Imazethapyr ^{ψψ}	200	7.2	73.6	81.0	4.0	74.1	73.2
Hand-weeding	25, 45 days*	0.3	68.2	78.3	0.0	71.6	70.9
Unweeded		0.0	68.2	77.7	0.0	71.1	70.9

Pre-plant incorporation; ^ψpre-emergence; ^{ψψ}early post-emergence; *Days, days after sowing; UC, unweeded check; HW, hand-weeding; Isop, isoproturon

were not significantly affected by the residues of imazethapyr at all its doses and time of application. Higher plant height and dry-matter accumulation of wheat were obtained with residues of imazethapyr 200 g/ha (pre-emergence). It shows that residues of imazethapyr at all the doses did not have any phytotoxic effect on wheat crop. The similar non-toxic residual effect of imazethapyr on wheat grown after rainy-season crop was also reported by Kee and Rider (1988).

The direct effect of weed-control treatments applied to wheat crop influenced the plant height and dry matter of wheat significantly during both the years, except plant height during the second year. The higher weed-control efficiency of isoproturon and hand-weeding over the

unweeded check increased the plant height and dry matter of wheat significantly. However, dry matter of wheat during first year was significantly higher with weed control through isoproturon over hand-weeding twice.

Similar to growth of wheat crop, the development (flowering and maturity) of this crop was not affected significantly by the residues of imazethapyr applied in soybean. The effect of treatments on growth and development is ultimately reflected in grain yield. The data in Table 4 reveal that due to non-significant effect of residues of imazethapyr on wheat growth and development, the grain yield was not affected significantly. However, due to the influence of residues of imazethapyr 200 g/ha (at all times of application) applied in

Table 3. Residual effect of imazethapyr applied in soybean and direct effect of weed-control treatments applied to wheat + pea on plant height (cm) and dry matter (g/m²) of wheat and pea crops

Treatment	Dose (g/ha)	Wheat				Pea			
		Plant height		Dry matter		Plant height		Dry matter	
		1990-91	1991-92	1990-91	1991-92	1990-91	1991-92	1990-91	1991-92
				<i>Residual effect</i>					
Imazethapyr [†]	50	110.11	111.00	960.00	957.78	59.67	66.80	7.56	8.09
Imazethapyr [‡]	50	110.00	111.78	965.00	960.00	60.00	67.31	7.47	8.04
Imazethapyr ^{¶¶}	50	111.67	111.56	966.67	961.67	59.97	67.00	7.44	8.13
Imazethapyr [†]	100	110.56	111.61	963.33	960.00	60.20	67.30	7.71	8.26
Imazethapyr [‡]	100	110.33	111.89	969.22	960.56	60.23	67.48	7.67	8.24
Imazethapyr ^{¶¶}	100	110.78	111.78	969.45	964.45	60.23	66.97	7.60	8.31
Imazethapyr [†]	150	110.89	111.39	969.56	965.00	60.14	67.67	7.77	8.40
Imazethapyr [‡]	150	111.89	112.42	978.89	962.78	60.40	67.89	7.79	8.40
Imazethapyr ^{¶¶}	150	111.11	112.33	978.89	965.56	60.40	67.16	7.80	8.38
Imazethapyr [†]	200	111.44	109.31	975.00	970.00	60.56	68.03	7.92	8.54
Imazethapyr [‡]	200	111.11	112.98	982.22	968.33	60.61	68.09	7.96	8.58
Imazethapyr ^{¶¶}	200	111.22	111.50	975.56	967.78	60.49	67.89	7.87	8.80
Hand-weeding	25, 45 days*	110.11	111.76	963.33	958.33	59.86	67.10	7.57	8.10
Unweeded		110.22	111.44	964.45	956.45	59.80	66.67	7.54	8.30
CD (P = 0.05)		NS	NS	NS	NS	NS	NS	NS	NS
<i>Wheat treatment</i>									
Unweeded		108.76	111.57	811.55	773.57	65.92	66.77	7.46	7.69
Hand-weeding	30, 60 days*	112.00	111.50	103.82	1,056.50	67.89	67.86	8.46	8.76
Isoproturon	1.0 kg/ha 35 days*	111.69	111.81	1,058.43	1,058.21	46.74	67.52	7.13	8.54
CD (P = 0.05)		1.56	NS	11.47	8.29	1.22	NS	0.55	0.44

[†]Pre-plant incorporation, [‡]pre-emergence, [¶]early post-emergence; *days after sowing

controlling the weeds of wheat + pea, numerically higher grain yield was obtained with these treatments. During the first year, isoproturon was significantly superior to hand-weeding in increasing the wheat grain yield, but during second year both were statistically at par.

Effect of treatment on pea

The residual effect of treatments applied in soybean did not influence the plant height and dry-matter accumulation of pea. It indicated that residues of imazethapyr even

at higher dose did not cause any phytotoxic effect on pea crop but because of its help in controlling the weeds associated with this crop, the plant height and dry matter increased numerically.

The direct effect of treatments applied to wheat + pea was significant on plant height and dry matter of pea (Table 3). The plant height of pea was significantly lower compared with hand-weeding twice and unweeded check during first year due to phytotoxic effect of 1.5 kg/ha of isoproturon. However, during second year the differences

Table 4. Residual effect of imazethapyr applied in soybean and direct effect of weed-control treatments applied to wheat + pea on grain yield on wheat, seed yield of pea and wheat-equivalent yield

Treatment	Dose (g/ha)	Grain yield (q/ha)		Pea-seed yield (q/ha)		Wheat-equivalent yield (q/ha)	
		1990—91	1991—92	1990—91	1991—92	1990—91	1991—92
<i>Residual effect</i>							
Imazethapyr [†]	50	38.04	39.16	4.23	5.04	49.35	50.47
Imazethapyr ^ψ	50	38.17	39.21	4.24	5.13	49.49	50.53
Imazethapyr ^{ψψ}	50	38.18	39.12	4.23	5.04	49.47	50.41
Imazethapyr [†]	100	38.74	39.45	4.16	5.16	49.84	50.85
Imazethapyr ^ψ	100	38.82	39.76	4.05	5.16	49.63	50.56
Imazethapyr ^{ψψ}	100	38.71	39.66	4.04	5.16	49.50	50.46
Imazethapyr [†]	150	39.36	40.38	4.06	5.20	50.20	51.22
Imazethapyr ^ψ	150	39.45	40.36	4.06	5.21	50.29	51.20
Imazethapyr ^{ψψ}	150	39.25	40.34	4.05	5.21	50.07	51.17
Imazethapyr [†]	200	39.91	41.29	4.08	5.23	50.80	52.17
Imazethapyr ^ψ	200	39.53	41.30	4.08	5.24	50.43	52.20
Imazethapyr ^{ψψ}	200	39.85	41.28	4.07	5.24	50.72	52.15
Hand-weeding	25, 45 days*	38.17	39.24	4.02	5.14	48.91	50.00
Unweeded		38.08	39.29	4.02	4.15	48.80	50.01
CD (P = 0.05)		NS	NS	NS	NS	NS	NS
<i>Wheat treatment</i>							
<i>Direct effect</i>							
Unweeded		27.07	27.71	3.22	3.70	35.65	36.29
Hand-weeding	30, 60 days*	43.90	46.17	5.95	6.15	59.78	62.04
Isoproturon 1.0 kg/ha	35 days	45.66	46.15	3.14	5.64	54.03	54.53
CD (P = 0.05)		0.92	1.04	0.10	0.10	0.98	1.00

[†]Pre-plant incorporation; ^ψpre-emergence; ^{ψψ}early post-emergence; *days after sowing

were not significant due to non-phytotoxic effect of 1.0 kg/ha of isoproturon. Unlike plant height, the phytotoxic effect of higher dose (1.5 kg/ha of isoproturon on dry-matter accumulation of pea was less, as it was statistically at par with unweeded check but was significantly lower from hand-weeding twice during first year. During the second year, dry matter was significantly higher when weeds were controlled with isoproturon 1.0 kg/ha compared with unweeded check.

The effect of treatments on growth and development of pea was reflected on seed yield of pea. Residues of imazethapyr did not influence the seed yield significantly. But the direct effect of treatments applied in wheat + pea was significant (Table 4). Hand-weeding twice resulted in significantly higher seed yield from the weed control through isoproturon, but during first year the phytotoxic effect of higher dose 1.5 kg/ha of isoproturon caused phytotoxicity on growth of pea and thus resulted in yield at par with unweeded check.

Wheat-equivalent yield

Like wheat and pea yields, the wheat-equivalent yield was also not affected significantly by residues of imazethapyr, but numerically higher wheat-equivalent yield was obtained with the residues of imazethapyr 200 g/ha. The direct effects of treatments applied to wheat + pea were significant on wheat-equivalent yield (Table

4). Due to significantly lower seed yield of pea in isoproturon treatment, significantly highest wheat-equivalent yield was obtained by controlling weeds with hand-weeding twice. No interaction was observed between residues of imazethapyr and direct effect of weed-control treatments applied to wheat + pea on yield of both the crops.

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