

Bio-efficacy of various herbicides and their mixtures on weeds and yield of wheat (*Triticum aestivum*) under subtropical agro-ecosystem

RAJEEV BHARAT AND DILEEP KACHROO

Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, J&K

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2004-05 and 2005-06 to study the effect of various herbicides and their mixtures on weed growth, yield attribute and yield of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) under irrigated conditions of subtropical agro-ecosystem of Jammu region. The weed flora observed at site were *Anagallis arvensis*, *Poa annua*, *Phalaris minor*, *Trachyspermum* and *Euphorbia helioscopia*, of which the relative density of individual weed species out of total weeds corresponds to 1.11 to 4.69 per cent on application of fenoxaprop+metribuzin (120+100 g ai/ha) at 60 days after sowing (DAS). Among the weed-control treatments, fenoxaprop+metribuzin (120+100 g ai/ha), though on a par with either tank mix application of sulfosulfuron + 2,4-D (25+500 g ai/ha), clodinafop + metsulfuron (60+2 g ai/ha), isoproturon+2,4-D (750+500 g ai/ha) or alone application of sulfosulfuron (25 g ai/ha), metribuzin (175 or 200 g ai/ha) and isoproturon (1,000 g ai/ha), reduced the dry weight of weeds significantly than weedy check and other herbicide treatments. It led to significant increase in the yield attributes, viz. effective tillers/m, grains/ear and 1,000-grain weight, and the yield of wheat than the rest of the treatments, during both the years of experimentation. Maximum grain yield and yield attributes were recorded in weed-free plots, and reduction of 42.29 and 38.27 per cent in yield was observed in weedy check plots during 2004-05 and 2005-06 respectively.

Key words: Herbicides, Weeds, Nutrient uptake, Economics, Yield, Wheat

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) occupies a prominent place as an important crop contributing 40 per cent in the total foodgrain production, and is next only to rice (*Oryza sativa* L.). In Jammu & Kashmir wheat is grown on 0.28 million ha land and contributes 0.34 million tonnes foodgrains, with an average productivity of 1.32 tonnes/ha (Anonymous, 2002). However, its productivity is quite low. Weeds are one of the major factors affecting the productivity, resulting in 30-50 per cent losses in crop yield (Dwivedi *et al.*, 1996), and therefore need immediate attention. Due to high fertility and irrigation requirement, wheat is infested with heavy population of *Phalaris minor*, *Avena ludoviciana*, *Chenopodium album*, *Vicia sativa*, *Melilotus indica* and other prominent weeds. Continuous use of isoproturon for 10-15 years in rice-wheat cropping system has led to development of resistance in *Phalaris minor* (Malik and Singh, 1993), necessitating a look for new alternative herbicides having different mechanism of action besides being selective to wheat and subsequent crop. Hence the present investigation was undertaken to test the efficacy of some new-generation herbicides along with widely used ones, i.e. isoproturon and 2,4-D, either

alone or in combination as mixtures against weeds in wheat under the subtropical conditions of Jammu region.

MATERIALS AND METHODS

A field experiment was conducted at the research farm, FOA, Main campus, Chatha of SKUAST-Jammu during winter (*rabi*) season of 2004-05 and 2005-06. The soil was sandy loam, slightly alkaline in reaction (7.1), low in organic carbon (0.48%) and available nitrogen (210 kg/ha), and medium in available phosphorus (15.5 kg/ha) and potassium (135 kg/ha). Wheat variety 'PBW 343' was sown in lines 20 cm apart by *kera* method on 4 November during both the years, using 100 kg seed/ha. Recommended dose of fertilizers (100 kg N, 60 kg P₂O₅ and 60 kg K₂O/ha) was uniformly applied to all the treatments. Full dose of P and K and half the dose of N were applied basal at the time of sowing and the rest N in two equal splits of one-fourth was top-dressed at crown-root initiation and booting stages during both the crop seasons. The experiment comprised 15 treatments, i.e. T₁, weedy check; T₂, weed-free treatment; T₃, isoproturon (1,000 g ai/ha); T₄, sulfosulfuron (25 g ai/ha); T₅, clodinafop (60 g ai/ha); T₆, fenoxaprop-*p*-ethyl (120 g ai/ha); T₇, 2,4-D

(750 g ai/ha); T₈, metsulfuron methyl (4 g ai/ha); T₉, metribuzin (175 g ai/ha); T₁₀, metribuzin (200 g ai/ha); T₁₁, sulfosulfuron+2,4-D (25+500 g ai/ha); T₁₂, isoproturon + 2,4-D (750+500 g ai/ha); T₁₃, clodinafop + 2,4-D (60+500 g ai/ha); T₁₄, clodinafop+metsulfuron methyl (60+2 g ai/ha); and T₁₅, fenoxaprop-*p*-ethyl + metribuzin (120+100 g ai/ha). These were arranged in randomized block design with three replications. Herbicide treatments were applied 30 days after sowing (DAS) with the help of knapsack sprayer fitted with flat-fan T-jet nozzle, at a spray volume of 500 litres/ha. Observations on weed composition and dry matter were recorded from two random quadrats of 0.25 m² in each plot.

RESULTS AND DISCUSSION

Weed flora

The major weed flora at the experimental site comprised broad-leaf weeds *Anagallis arvensis*, *Trachyspermum* spp. and *Euphorbia helioscopia*; and grassy weeds *Poa annua* and *Phalaris minor*. The relative density of individual weed species in percentage of total weed density at various stages of crop growth during both the crop seasons under weedy check conditions is given in Table 1. It shows that during 2004-05 and 2005-06 the infestation with grassy weeds was maximum during 60-90 days after sowing (DAS), ranging from 54.22 to 55.62 per cent respectively. Among the grasses, *Poa annua* was 48.52, 51.15, 52.59 and 44.10 per cent at 30, 60, 90 and 120 DAS respectively.

However, the response of these herbicides on relative density of individual weed species at 60 DAS (Table 2) revealed that the highest relative density of *Poa annua* was found in weedy check (51.15%), whereas the application of metribuzin alone at 200 g ai/ha gave effective control, followed by that of metribuzin (175 g ai/ha), fenoxaprop+metribuzin (120+100 g ai/ha) and their alone application. Similarly, the lowest relative density of *Phalaris minor* out of the total weed density was found on application of either fenoxaprop (120 g ai/ha),

sulfosulfuron (25 g ai/ha) or isoproturon (1,000 g ai/ha) or their combinations with metribuzin and 2,4-D. The weeds mainly *Trachyspermum* spp., *Anagallis arvensis* and *Euphorbia helioscopia* were minimum in per cent relative density when metribuzin alone at 200 g ai/ha or in combination with fenoxaprop (120+100 g ai/ha) was applied, which was closely followed by sulfosulfuron (25 g ai/ha) alone or as tank mix with 2,4-D (25+500 g ai/ha). This may be due to the effective control of grassy weeds by fenoxaprop and broad-spectrum effect of sulfosulfuron and metribuzin, which might have interfered in the photosynthetic apparatus of these weed species, thereby causing their mortality.

Weed population and dry weight

Different weed-control treatments significantly decreased the total number of weeds and their dry weights compared with the weedy check at 60 DAS during both the crop seasons (Table 3). Among the herbicides, application of tank mixture of fenoxaprop+metribuzin (120+100 g ai/ha), though being statistically on a par with either tank mix application of sulfosulfuron + 2,4-D (25+500 g ai/ha), clodinafop + metsulfuron (g ai/ha), isoproturon + 2,4-D (750+500 g ai/ha) or application of metribuzin alone both at 175 or 200 g ai/ha, reduced the total weed population significantly than the weedy check and other herbicide treatments at 60 DAS during both the crop seasons. Similarly, though a similar trend was observed with all the applied herbicides in reduction of dry weight of weeds during both the years of experimentation, application of sulfosulfuron alone (25 g ai/ha) and isoproturon alone (1,000 g ai/ha) proved similar to these treatments during 2004-05 and 2005-06 respectively. This may be because sulfosulfuron, isoproturon and metribuzin are broad-spectrum herbicides, whereas the tank mixtures of clodinafop, fenoxaprop, sulfosulfuron and isoproturon with either 2,4-D or metribuzin at reduced doses may have acted synergistically in broadening the spectrum of weed control. These results are in conformity with those of Singh *et al.*

Table 1. Relative density of individual weed species in percentage of the total weed density at various stages of crop growth under weedy conditions

Weed species	2004-05 (days after sowing)				2005-06 (days after sowing)			
	30	60	90	120	30	60	90	120
<i>Grassy weed</i>								
<i>Poa annua</i>	48.52	51.15	52.59	44.10	52.80	47.54	51.83	40.56
<i>Phalaris minor</i>	2.37	3.07	3.03	4.67	4.45	7.14	7.13	17.34
<i>Broad-leaf weed</i>								
<i>Trachyspermum</i> spp.	13.31	11.12	10.52	13.75	10.33	12.72	8.86	10.22
<i>Anagallis arvensis</i>	19.53	13.79	13.19	16.08	10.62	12.05	10.21	13.31
<i>Euphorbia helioscopia</i>	12.13	9.20	9.27	11.93	5.17	10.27	7.90	11.15
Others	4.14	11.67	11.40	9.47	16.63	10.28	14.07	7.42

Table 2. Density of different weeds (60 DAS) in wheat as influenced by different herbicides during both the years

Treatment	Dose (g ai/ha)	<i>Poa annua</i>		<i>Phalaris minor</i>		<i>Trachyspermum sp.</i>		<i>Anagallis arvensis</i>		<i>Euphorbia helioscopia</i>	
		2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Weedy check		13.60 (178.00)	11.94 (142.00)	3.34 (10.67)	4.67 (21.33)	6.23 (38.67)	6.20 (38.00)	6.94 (48.00)	6.04 (36.00)	5.69 (32.00)	5.55 (30.67)
Weed-free treatment		0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Isoproturon	1,000	7.40 (54.33)	5.64 (31.33)	1.60 (3.33)	2.92 (8.00)	3.23 (10.00)	3.23 (10.00)	3.96 (15.33)	3.21 (10.00)	3.23 (10.00)	2.90 (8.00)
Sulfosulfuron	25	5.78 (32.67)	4.60 (20.67)	1.68 (2.33)	2.68 (6.67)	2.41 (5.33)	2.79 (7.33)	3.42 (11.33)	2.90 (8.00)	2.90 (8.00)	2.53 (6.00)
Clodinafop	60	5.70 (32.00)	4.95 (24.00)	1.35 (1.33)	1.96 (3.33)	5.98 (37.33)	6.09 (36.67)	6.67 (44.00)	5.86 (34.00)	5.63 (31.33)	5.41 (29.33)
Fenoxaprop	120	5.34 (28.00)	3.58 (12.33)	1.35 (1.33)	1.78 (2.67)	5.74 (32.67)	5.64 (31.33)	6.52 (42.00)	5.92 (34.00)	5.07 (25.33)	5.33 (28.00)
2,4-D	750	13.13 (172.00)	11.68 (136.00)	3.24 (10.00)	4.53 (20.00)	2.27 (4.67)	1.94 (3.33)	1.96 (3.33)	1.76 (2.67)	1.78 (2.67)	2.08 (4.00)
Metsulfuron methyl	4	12.52 (156.33)	10.95 (119.33)	3.14 (9.33)	4.38 (18.67)	1.58 (2.00)	1.76 (2.67)	1.47 (2.00)	1.58 (2.00)	1.78 (2.67)	1.58 (2.00)
Metribuzin	175	4.78 (22.33)	2.27 (4.67)	3.03 (8.67)	4.30 (18.00)	1.65 (2.67)	2.26 (4.67)	1.35 (1.33)	1.94 (3.33)	2.53 (6.00)	2.08 (4.00)
Metribuzin	200	3.81 (5.46)	2.48 (5.67)	2.97 (8.33)	4.22 (17.33)	1.29 (1.33)	1.76 (2.67)	1.00 (0.67)	1.35 (1.33)	1.94 (3.33)	1.96 (3.33)
Sulfosulfuron + 2,4-D	25+500	5.46 (29.33)	2.61 (6.33)	1.58 (2.00)	2.27 (4.67)	1.94 (3.33)	2.26 (4.67)	2.12 (4.00)	1.76 (2.67)	2.06 (4.67)	1.96 (3.33)
Isoproturon+2,4-D	750+500	6.07 (36.33)	3.19 (9.67)	1.78 (2.67)	2.42 (5.33)	2.27 (4.67)	2.67 (6.67)	2.72 (9.33)	2.39 (5.33)	2.65 (6.67)	2.23 (4.67)
Clodinafop+2,4-D	60+500	12.34 (151.67)	11.42 (130.00)	3.14 (9.33)	3.98 (15.233)	3.86 (14.67)	3.86 (14.67)	4.93 (24.67)	4.30 (18.00)	3.51 (12.00)	3.24 (10.67)
Clodinafop+metsulfuron	60.2	5.34 (28.00)	2.80 (7.33)	1.35 (1.333)	2.27 (4.67)	2.26 (4.67)	1.94 (3.33)	3.11 (9.33)	2.27 (4.67)	2.79 (7.33)	1.94 (3.33)
Fenoxaprop+metribuzin	120+100	3.94 (15.00)	3.81 (14.00)	2.92 (8.00)	3.89 (14.67)	2.08 (4.00)	2.12 (4.00)	2.39 (6.67)	1.76 (2.67)	2.53 (6.00)	1.96 (3.33)
CD (P=0.05)		2.41	2.73	0.78	1.18	1.34	1.06	1.38	0.64	1.20	1.01

Data subjected to square-root ($\sqrt{x+0.5}$) transformation; Figures in parentheses are original values

Table 3. Effect of various treatments on weed population, dry weight and weed-control efficiency at 60 DAS in wheat during both the years

Treatment	Dose (g ai/ha)	Weed population (no./m ²)		Dry weight of weeds (g/m ²)		Weed-control efficiency (%)	
		2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Weedy check		18.67 (348.00)	17.30 (298.67)	5.90 (34.31)	5.55 (30.35)		
Weed-free treatment		0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.00	100.00
Isoproturon	1,000	9.81 (96.67)	9.77 (95.00)	3.35 (10.72)	3.11 (9.19)	68.75	69.71
Sulfosulfuron	25	8.28 (68.00)	8.48 (71.33)	3.37 (10.85)	2.86 (7.70)	68.39	74.64
Clodinafop	60	13.24 (174.67)	11.51 (132.00)	4.59 (20.54)	4.00 (15.33)	40.13	48.83
Fenoxaprop	120	12.83 (164.00)	10.50 (109.67)	4.31 (18.08)	3.89 (14.65)	47.30	51.72
2,4-D	750	14.57 (213.67)	13.51 (182.00)	4.13 (16.60)	3.93 (14.92)	51.63	50.85
Metsulfuron methyl	4	14.16 (200.00)	12.55 (157.00)	4.03 (15.73)	3.83 (14.18)	54.15	53.29
Metribuzin	175	7.38 (54.00)	6.92 (54.00)	2.71 (6.86)	2.55 (5.99)	80.00	80.26
Metribuzin	200	6.47 (41.33)	6.39 (39.33)	2.50 (5.74)	2.33 (4.93)	83.28	83.75
Sulfosulfuron + 2,4-D	25+500	7.34 (55.33)	5.87 (33.67)	2.67 (6.64)	2.41 (5.29)	80.65	82.58
Isoproturon+2,4-D	750+500	7.86 (61.33)	6.67 (44.00)	2.89 (7.84)	2.75 (7.04)	77.14	76.79
Clodinafop+2,4-D	60+500	14.84 (219.67)	14.76 (217.33)	4.79 (22.48)	4.79 (22.49)	34.48	25.90
Clodinafop+metsulfuron	60+2	7.25 (52.00)	6.62 (43.33)	3.01 (8.55)	2.56 (6.05)	75.08	80.08
Fenoxaprop+metribuzin	120+100	6.57 (42.67)	7.11 (50.00)	2.49 (5.70)	3.03 (8.69)	83.40	71.38
CD (P=0.05)		1.56	1.33	1.22	0.89		

Data subjected to square-root ($\sqrt{x+0.5}$) transformation; Figures in parentheses are original values

(2003) and Punia *et al.*, 2004). Maximum weed-control efficiency was observed with the application of fenoxaprop+metribuzin (120+100 g ai/ha) and sulfosulfuron + 2,4-D (25+500 g ai/ha) respectively during both the years of experimentation. The higher weed-control efficiency may be attributed to lower dry weight of weeds.

Yield and yield attributes

Maximum yield attributes and yield were recorded in weed-free plots during both the crop seasons, because no weeds were observed in weed-free plots, which may have resulted in increased nutrient, water, space and light supply to the wheat crop due to absence of crop-weed competition. This in turn might have resulted in greater photosynthesis and hence better translocation of photosynthates besides larger sink and stronger reproductive phase, as reflected in maximum effective tillers/m, grains/ear and

1,000-grain weight (Table 4). Among the herbicides, tank mix application of fenoxaprop+metribuzin (120+100 g ai/ha), isoproturon + 2,4-D (750+500 g ai/ha), clodinafop + metsulfuron (60+2 g ai/ha), isoproturon + 2,4-D (750+500 g ai/ha) or alone application of metribuzin both at 175 or 200 g ai/ha, sulfosulfuron (25 g ai/ha) and isoproturon (1,000 g ai/ha), though statistically on a par with each other, increased the yield attributes of wheat, viz. grains/ear and 1,000-grain weight, significantly compared with weedy check and other herbicide treatments. Though similar trend was observed for effective tillers/m of wheat except with application of metribuzin (175 or 200 g ai/ha), it was not similar to these treatments during both the years of experimentation, perhaps due to phytotoxic effects of metribuzin on wheat at either doses. Sharma (2003) expressed similar views.

Among the herbicide treatments, tank mix application of fenoxaprop+metribuzin (120+100 g ai/ha),

Table 4. Yield attributes and benefit:cost ratio of wheat as influenced by various herbicides during both the years

Treatment	Dose (g ai/ha)	Effective tillers/m		Grains/ear		1,000-grain weight (g)		Grain yield (q/ha)		Benefit:cost ratio	
		2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Weedy check		49.83	50.53	29.57	31.73	34.05	34.72	28.69	31.67	0.88	1.11
Weed-free treatment		66.17	70.33	43.60	44.03	41.59	42.11	49.71	51.30	1.10	1.12
Isoproturon	1,000	59.33	63.83	36.57	39.47	39.82	39.70	42.15	44.18	1.55	1.74
Sulfosulfuron	25	60.00	65.00	37.47	40.13	39.95	39.79	43.58	46.27	1.37	1.59
Clodinafop	60	54.50	55.67	33.57	37.17	37.75	37.40	37.98	39.58	1.09	1.24
Fenoxaprop	120	58.33	60.83	35.50	36.73	38.42	38.12	40.19	43.37	1.15	1.38
2,4-D	750	56.83	59.00	35.20	35.57	37.90	37.67	38.82	41.75	1.37	1.59
Metsulfuron methyl	4	58.67	60.33	35.77	35.73	39.69	37.69	40.87	52.41	1.47	1.63
Metribuzin	175	57.83	60.17	38.53	39.90	40.86	40.43	41.88	44.02	1.52	1.72
Metribuzin	200	55.67	57.00	36.50	38.73	40.57	40.42	41.32	43.58	1.49	1.69
Sulfosulfuron + 2,4-D	25+500	64.00	68.50	40.57	42.77	40.28	40.48	45.84	49.83	1.44	1.71
Isoproturon+2,4-D	750+500	63.67	67.50	39.83	41.40	40.06	40.02	45.46	47.74	1.68	1.90
Clodinafop+2,4-D	60+500	55.67	56.33	33.67	36.50	37.96	37.44	39.93	40.45	1.14	1.24
Clodinafop+metsulfuron	60+2	62.33	66.83	39.53	42.50	39.99	40.41	44.65	48.70	1.37	1.64
Fenoxaprop+metribuzin	120+100	64.67	63.00	42.13	39.17	40.54	39.66	46.36	44.10	1.41	1.39
CD (P=0.05)		5.51	5.84	5.93	4.37	0.84	1.02	4.51	5.73		

sulfosulfuron + 2,4-D (25+500 g ai/ha), clodinafop + metsulfuron (60+2 g ai/ha), isoproturon + 2,4-D (750+500 g ai/ha) or alone application of metribuzin (175 g ai/ha), sulfosulfuron (25 g ai/ha) and isoproturon (1,000 g ai/ha) applied at 30 days stage of wheat during 2004-05, though on a par with each other, increased the yield of wheat significantly compared with weedy check and other herbicide treatments. However, though a similar trend was observed with all the applied herbicides, application of metribuzin (175 g ai/ha) was not found similar to these treatments during the second year of experimentation. However, tank mix application of fenoxaprop+metribuzin (120+100 g ai/ha), sulfosulfuron + 2,4-D (25+500 g ai/ha) and isoproturon + 2,4-D (750+500 g ai/ha) gave yield similar to that of weed-free plots during 2004-05, whereas application of sulfosulfuron (25 g ai/ha) and clodinafop + metsulfuron (60+2 g ai/ha) proved similar to that of weed-free plots during the second crop season. However, fenoxaprop+metribuzin (120 + 100 g ai/ha) was not similar to these treatments during the second year, because of lower weed population and dry weight of weeds due to significant control of weeds by these treatments, which might have shifted the competition for moisture, nutrients, space and light in favour of the crop rather than of weeds. These results are in close conformity with those reported by Singh *et al.* (1998, 2003), Azad *et al.* (2003) and Punia *et al.* (2004).

Nutrient studies

N, P and K uptake by weeds at harvest

Among the applied herbicides, tank mixture of sulfosulfuron + 2,4-D (25+500 g ai/ha), though on a par

with tank mixture of isoproturon + 2,4-D (750+500 g ai/ha) and clodinafop+metsulfuron (60+2 g ai/ha), significantly reduced the N, P and K uptake by weeds compared with the weedy check and other herbicide treatments at harvest stage during 2004-05 and 2005-06 respectively (Table 5). However, the application of fenoxaprop + metribuzin (120+100 g ai/ha), metribuzin (175 or 200 g ai/ha), 2,4-D (750 g ai/ha) and metsulfuron methyl (4 g ai/ha) during 2004-05 proved significantly equally effective in reducing the N, P and K uptake by weeds than other treatments.

N, P and K uptake by wheat at harvest

Application of fenoxaprop+metribuzin (120+100 g ai/ha), though on a par with tank mixture of sulfosulfuron + 2,4-D (25+500 g ai/ha), isoproturon+2,4-D (750+500 g ai/ha) and clodinafop + metsulfuron (60+2 g ai/ha) besides alone application of sulfosulfuron (25 g ai/ha) applied at 30 DAS during 2004-05, resulted in maximum N and P uptake and differed significantly than weedy check and other herbicide treatments at harvest stage (Table 5). However, sulfosulfuron (25 g ai/ha) was not similar to these treatments in increasing the K uptake by weeds significantly. During 2005-06, though a similar trend was observed with all the applied herbicides, the application of tank mixture of fenoxaprop+metribuzin (120+100 g ai/ha) was not similar to these treatments.

Economics

The benefit:cost (B:C) ratio as influenced by various herbicide treatments (Table 4) reveals that minimum cost of cultivation was observed in weedy check plots and the

Table 5. Total N, P and K uptake by wheat and weeds in wheat as influenced by various herbicides at harvest stage during both the years

Treatment	Dose (g ai/ha)	N uptake (kg/ha)				P uptake (kg/ha)				K uptake (kg/ha)			
		Wheat		Weeds		Wheat		Weeds		Wheat		Weeds	
		2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Weedy check		70.30	79.89	5.86 (34.22)	6.15 (37.74)	6.21	6.84	2.13 (4.09)	2.24 (4.57)	109.36	121.21	6.16 (37.43)	6.44 (40.95)
Weed-free treatment		119.85	126.62	0.71 (0.00)	0.71 (0.00)	9.85	10.16	0.71 (0.00)	0.71 (0.00)	157.10	162.77	0.71 (0.00)	0.71 (0.00)
Isoproturon	1,000	101.69	109.92	3.32 (10.58)	2.88 (7.87)	8.55	9.00	1.33 (1.27)	1.20 (0.94)	140.70	149.94	3.50 (11.72)	2.99 (8.45)
Sulfosulfuron	25	104.12	113.47	2.74 (7.03)	2.36 (5.09)	8.76	9.31	1.16 (0.85)	1.05 (0.61)	142.24	152.01	2.86 (7.69)	2.43 (5.41)
Clodinafop	60	89.74	94.76	5.38 (28.47)	5.48 (29.53)	7.76	8.14	1.98 (3.41)	1.99 (3.47)	127.93	136.70	5.57 (30.50)	5.64 (31.31)
Fenoxaprop	120	97.20	103.85	5.41 (29.38)	5.41 (28.81)	8.17	8.80	1.99 (3.52)	1.98 (3.14)	134.91	145.38	5.72 (32.21)	5.55 (30.28)
2,4-D	750	94.98	100.68	1.49 (1.91)	2.90 (7.94)	7.98	8.52	0.84 (0.21)	1.20 (0.93)	133.74	142.23	1.54 (1.86)	2.94 (8.16)
Metsulfuron methyl	4	98.54	102.23	1.51 (1.80)	2.84 (7.61)	8.29	8.65	0.85 (0.22)	1.19 (0.91)	136.22	144.34	1.57 (1.98)	2.89 (7.83)
Metribuzin	175	101.50	107.76	1.85 (2.93)	2.14 (4.13)	8.44	8.93	0.92 (0.36)	0.99 (0.49)	137.57	147.76	1.94 (3.25)	2.21 (4.39)
Metribuzin	200	100.71	106.83	1.71 (2.43)	1.92 (3.20)	8.37	8.85	0.89 (0.29)	0.94 (0.38)	137.50	146.74	1.78 (2.66)	1.98 (3.44)
Sulfosulfuron + 2,4-D	25+500	112.10	120.40	1.57 (1.98)	1.33 (1.26)	9.16	9.95	0.86 (0.24)	0.81 (0.15)	149.67	161.68	1.63 (2.15)	1.34 (1.31)
Isoproturon+2,4-D	750+500	111.16	117.01	1.70 (3.01)	1.77 (2.66)	9.12	9.66	0.91 (0.36)	0.90 (0.31)	148.38	160.02	1.95 (3.30)	1.81 (2.76)
Clodinafop+2,4-D	60+500	98.55	98.58	2.82 (8.67)	3.90 (14.75)	8.15	8.34	1.21 (1.05)	1.50 (1.76)	134.59	138.16	3.13 (9.31)	3.91 (14.81)
Clodinafop+metsulfuron	60+2	105.89	117.83	2.02 (3.60)	1.43 (1.64)	8.92	9.74	0.96 (0.43)	0.83 (0.20)	145.29	158.52	2.11 (3.96)	1.49 (1.72)
Fenoxaprop+metribuzin	120+100	113.20	109.67	1.51 (1.80)	3.20 (9.74)	9.29	8.98	0.85 (0.22)	1.29 (1.17)	150.84	149.48	1.57 (1.95)	3.26 (10.14)
CD (P=0.05)		9.14	9.36	1.08	0.47	0.64	0.77	0.30	0.14	7.13	8.08	1.12	0.49

Data subjected to square-root ($\sqrt{x+0.5}$) transformation; Figures in parentheses are original values

maximum returns were obtained in weed-free plots during both the years. However, higher B:C ratio was observed in the plots treated with tank mixture of isoproturon + 2,4-D (750+500 g ai/ha), followed by alone application of isoproturon (1,000 g ai/ha) and metribuzin (175 g ai/ha) respectively, and the minimum B:C ratio was recorded in weedy check plots (1.11) on an average during both the years of experimentation.

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