Indian J. Weed Sci. **36** (1 & 2) : 41-46 (2004)

Evaluation of Triasulfuron Alone and as Tank Mixture with Clodinafop, Fenoxaprop, Sulfosulfuron or Tralkoxydim against Complex Weed Flora in Wheat

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ABSTRACT

Weed control efficacy of clodinafop at 50 g, fenoxaprop at 100 g, sulfosulfuron at 20 g and tralkoxydim at 300 g ha^{-1} ranged between 78-96% on grassy weeds. These herbicides were totally ineffective against broadleaf weeds except sulfosulfuron. Triasulfuron was not effective against grassy weeds, but very effective on all broadleaf weeds. The efficacy of clodinafop at all combinations with triasulfuron was reduced in controlling grassy weeds. However, efficacy of triasulfuron was not affected due to tank mixing.

INTRODUCTION

High yielding dwarf wheat varieties coupled with improved facilities of irrigation and fertilizers have led to the problem of grassy weeds particularly littleseed canary grass (*Phalaris minor* Retz.) in rice-wheat cropping areas and wild oat (*Avena ludoviciana* Dur.) in the areas with light textured, irrigated and well-drained soils. *P. minor* has also evolved resistance against isoproturon due to its continuous use and mono-cropping sequence of rice-wheat (Malik and Singh, 1995) and now resistant biotypes require 6.5 to 11 times more isoproturon to obtain 50% growth reduction as compared to prestine populations of *P. minor* (Yadav *et al.*, 1996, 1997, 2002). In many parts of India, infestation of either or both of grassy weeds together alongwith some broadleaf weeds also occurs in wheat causing huge losses and making the problem more complex (Malik *et al.*, 1992; Balyan, 2001; Singh and Singh, 2002a).

Tank mixture of isoproturon with 2, 4-D (Balyan and Malik, 1988; Malik *et al.*, 1992) or with metsulfuron-methyl (Yadav *et al.*, 2000; Singh and Singh, 2002a) and many other herbicidal combinations were found successful against complex weed flora in the past. To manage resistant *Phalaris,* alternate herbicides, namely, clodinafop-propargyl, fenoxaprop-p-ethyl, sulfosulfuron and tralkoxydim were recommended in 1997. These herbicides are basically wild oat targeted and frequently being used in other parts of world against this weed. Therefore, there is a need to exploit the possibilities of their success against complex flora of weeds in wheat. 2, 4-D or metsulfuron-methyl tank mixture with these herbicides has been found antagonistic against *P. minor* (Yadav *et al.*, 2002). Hence, present investigation was planned to evaluate the efficacy of triasulfuron alone and in combination with each of four alternate herbicides against complex weed flora in wheat.

MATERIALS AND METHODS

Four separate field experiments were conducted during 2000-01 and 2001-02 at Research Farm of CCS Haryana Agricultural University, Hisar, India. The experiments in both the years were conducted in the same field having sandy loam soil low in available N (112.7 kg ha^{-1}), medium in P_2O_5 (16.2 kg ha^{-1}) and high in K_2O (509.0 kg ha^{-1}) with pH 8.2. What variety PBW 343 at 87.5 kg seed ha^{-1} was sown on beds on November 11 and October 27

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during 2000-01 and 2001-02, respectively. Two rows of wheat/bed were grown during both the years and the crop was raised with all recommended package of practices.

Each experiment comprising 15 treatments was laid out in randomized block design replicated thrice. Clodinafop propargyl (Table 1), fenoxaprop-p-ethyl (Table 2), sulfosulfuron (Table 3) and tralkoxydim (Table 4) at various doses were applied alone and as tank mixture with various doses of triasulfuron, and sprayed at 35 days after sowing (DAS) with knapsack sprayer fitted with flat fan nozzles using 500 l water ha^{-1}.

During 2000-01, the experimental field was infested with *A. ludoviciana* (30%), *P. minor* (10%), *Chenopodium album* (30%), *Melilotus* spp. (15%), *Rumex retroflex* (5%), *Fumaria parviflora* (7%) and *Convolvulus arvensis* (3%). During 2001-02, the relative density of *A. ludoviciana, P. minor, Melilotus* spp., *C. album, R. retroflex, Coronopus didymus* and *Spergula arvensis* was 33, 15, 27, 5, 8, 7 and 5%, respectively.

The data on dry weight of two grassy weeds (*A. ludoviciana* and *P. minor* combined) and various broadleaf weeds (together) were recorded at 90 DAS by randomly placing three quadrats (0.5 m x 0.5 m size)/plot and separately drying grassy and broadleaf weeds till constant weight was obtained.

RESULTS AND DISCUSSION

Effect on Weeds

Clodinafop, fenoxaprop, sulfosulfuron and tralkoxydim at all doses significantly reduced the dry weight of grassy weeds during both the years. Clodinafop at 50 g (Table 1), fenoxaprop at 100 g (Table 2), sulfosulfuron at 20 g (Table 3) and tralkoxydim at 300 g ha^{-1} (Table 4) each being at par

Table 1. Effect of triasulfuron and clodinafop alone and in combination on dry weight of weeds and grain yield of wheat

Herbicide	Dose (g ha^{-1})	Dry weight (g m^{-2}) of grassy weeds		Dry weight (g m^{-2}) of broadleaf weeds		Grain yield of wheat (kg ha^{-1})	
		2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Clodinafop	40	31.5	20.5	75.3	80.2	4295	4260
Clodinafop	50	26.1	14.5	80.5	87.6	4320	4698
Clodinafop	60	8.0	9.6	77.6	95.4	4642	4896
Triasulfuron	10	221.4	122.0	16.9	29.4	3883	4020
Triasulfuron	20	213.8	127.9	8.1	12.2	4130	4475
Triasulfuron	40	218.7	126.4	4.2	7.9	4250	4480
Triasulfuron	60	215.6	130.6	2.2	5.5	4370	4515
Triasulfuron+ Clodinafop	13.3+ 26.7	107.3	38.6	15.0	18.4	4375	4584
Triasulfuron+ Clodinafop	16.6+ 33.4	72.0	30.2	13.7	16.5	4405	4695
Triasulfuron+ Clodinafop	20+ 40	50.9	27.7	8.4	8.6	4646	5145
Triasulfuron+ Clodinafop	16+ 24	118.1	39.8	12.9	22.6	4200	4505
Triasulfuron+ Clodinafop	20+ 30	93.8	30.2	9.4	17.1	4276	4708
Triasulfuron+ Clodinafop	24+ 36	69.2	26.5	6.7	13.5	4638	5038
Weedy	-	209.5	120.7	75.1	61.2	3570	3820
Weed-free	-	0.0	0.0	0.0	0.0	4860	5458
LSD (P=0.05)		18.4	9.3	6.1	10.4	249	437

Table 2. Effect of triasulfuron and fenoxaprop alone and in combination on dry weight of weeds and grain yield of wheat

Herbicide	Dose (g ha^{-1})	Dry weight (g m^{-2}) of grassy weeds		Dry weight (g m^{-2}) of broadleaf weeds		Grain yield of wheat (kg ha^{-1})	
		2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Fenoxaprop	80	78.5	21.4	65.3	58.4	4235	4372
Fenoxaprop	100	47.6	14.3	62.4	62.6	4450	4806
Fenoxaprop	120	28.7	8.9	67.2	66.7	4480	4990
Triasulfuron	10	251.0	185.7	15.6	16.1	4005	4037
Triasulfuron	20	246.5	191.6	8.0	8.0	4290	4600
Triasulfuron	40	239.2	197.5	4.9	4.8	4372	4617
Triasulfuron	60	248.4	201.4	2.1	3.2	4390	4650
Triasulfuron+ Fenoxaprop	16+ 64	133.0	67.7	12.8	15.0	4410	4700
Triasulfuron+ Fenoxaprop	20+ 80	126.2	39.2	10.2	12.3	4465	4725
Triasulfuron+ Fenoxaprop	24+ 96	75.4	32.1	7.4	8.0	4620	5266
Triasulfuron+ Fenoxaprop	13.3+ 66.7	116.9	40.9	16.0	22.5	4460	4620
Triasulfuron+ Fenoxaprop	16.6 83.4	99.8	35.6	12.6	14.5	4462	4800
Triasulfuron+ Fenoxaprop	20+ 100	80.3	21.4	8.9	11.8	4675	5170
Weedy	-	237.1	178.2	62.5	53.6	3280	3635
Weed-free	-	0.0	0.0	0.0	0.0	4762	5405
LSD (P=0.05)		16.2	6.0	5.3	5.3	285	408

Table 3. Effect of triasulfuron and sulfosulfuron alone and in combination on dry weight of weeds and grain yield of wheat

Herbicide	Dose (g ha^{-1})	Dry weight (g m^{-2}) of grassy weeds		Dry weight (g m^{-2}) of broadleaf weeds		Grain yield of wheat (kg ha^{-1})	
		2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Sulfosulfuron	15	93.1	51.9	18.3	35.4	4570	4808
Sulfosulfuron	20	52.8	25.2	13.4	26.9	4652	5160
Sulfosulfuron	25	28.2	15.7	11.7	22.6	4780	5195
Triasulfuron	10	251.0	158.6	10.1	30.4	4028	4027
Triasulfuron	20	247.5	171.9	3.9	12.0	4390	4475
Triasulfuron	40	240.6	176.0	3.0	8.5	4526	4510
Triasulfuron	60	244.8	180.2	1.5	5.6	4430	4550
Triasulfuron+ Sulfosulfuron	7.5+ 7.5	138.3	74.0	4.0	33.3	4486	4698
Triasulfuron+ Sulfosulfuron	10+ 10	127.4	66.2	2.1	22.6	4560	4763
Triasulfuron+ Sulfosulfuron	12.5+ 12.5	102.0	59.8	1.8	21.2	4695	4885
Triasulfuron+ Sulfosulfuron	5+ 10	117.9	67.7	5.2	26.2	4500	4756
Triasulfuron+ Sulfosulfuron	6.6+ 13.4	94.5	55.1	3.7	23.4	4705	4870
Triasulfuorn+ Sulfosulfuron	8.3+ 16.7	67.9	44.1	2.7	21.2	4720	5015
Weedy	-	239.6	157.5	50.4	70.8	3277	3646
Weed-free	-	0.0	0.0	0.0	0.0	4980	5360
LSD (P=0.05)		31.2	12.3	4.7	8.8	341	389

Table 4. Effect of triasulfuron and tralkoxydim alone and in combination on dry weight of weeds and grain yield of wheat

Herbicide	Dose ($g\ ha^{-1}$)	Dry weight ($g\ m^{-2}$) of grassy weeds		Dry weight ($g\ m^{-2}$) of broadleaf weeds		Grain yield of wheat ($kg\ ha^{-1}$)	
		2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Tralkoxydim	250	45.4	42.5	58.0	87.6	4290	4117
Tralkoxydim	300	31.9	31.2	56.7	86.9	4327	4500
Tralkoxydim	350	14.7	21.3	59.6	90.2	4550	4830
Triasulfuron	10	161.3	145.6	16.9	36.4	4135	3845
Triasulfuron	20	157.6	151.5	10.0	15.6	4280	4326
Triasulfuron	40	150.2	144.8	5.2	8.7	4295	4478
Triasulfuron	60	155.5	159.7	3.7	6.1	4398	4600
Triasulfuron+ Tralkoxydim	15.3+ 234.7	109.7	66.6	11.9	23.4	4300	4634
Triasulfuron+ Tralkoxydim	18.7+ 281.3	92.3	52.5	13.4	17.3	4428	4810
Triasulfuron+ Tralkoxydim	21.8+ 328.2	69.6	45.4	7.5	11.3	4595	4997
Triasulfuron+ Tralkoxydim	11.9+ 238.1	61.0	70.9	15.0	45.9	4585	4796
Triasulfuron+ Tralkoxydim	14.3+ 285.7	52.0	42.5	12.6	32.9	4616	4950
Triasulfuron+ Tralkoxydim	16.6+ 333.4	48.9	25.5	9.8	26.0	4660	5075
Weedy	-	149.5	141.8	54.6	86.7	3700	3548
Weed-free	-	0.0	0.0	0.0	0.0	4810	5392
LSD (P=0.05)		17.7	9.7	5.5	10.4	276	398

were superior to their respective lower doses with respect to dry weight of grassy weeds, and their WCE ranged between 78-96%. None of these herbicides was effective against broadleaf weeds when used alone except sulfosulfuron. Sulfosulfuron also controlled broadleaf weeds to the extent of 50, 62 and 68% in first year and 64, 73 and 77% during second year (Table 3) at 15, 20 and 25 g ha^{-1}, respectively. These results are in conformity with earlier findings of Malik *et al.* (2000).

Triasulfuron at 10, 20 and 60 g ha^{-1} was ineffective against grassy weeds, but very effective against all broadleaf weeds except *C. arvensis* in 2000-01 (Tables 1, 2, 3 and 4). However, triasulfuron at 20, 40 and 60 g ha^{-1} was more effective than at 10 g $ha^{-1}$and reduced the dry weight of broadleaf weeds to the extent of 80-94% (Tables 1, 2, 3 and 4).

Tank mixture of triasulfuron with different herbicides at various doses also resulted in significant reduction in dry weight of grassy as well as broadleaf weeds (Tables 1, 2, 3 and 4). Combination of triasulfuron and clodinafop at 50 and 60 g ha^{-1} each in the ratio of 1 : 2 or 1 : 15 being at par with each other was superior to their use at 40 g ha^{-1} (Table 1). Triasulfuron+fenoxaprop at 100 and 120 g ha^{-1} mixed in the ratio of 1 : 4 was superior to its lower dose (Table 2), and reduced dry weight of grassy and broadleaf weeds to the tune of 47-82 and 77-88%, respectively. However, tank mixture of these two herbicides in the ratio of 1 : 5 at respective doses was more effective against wild oat but less against broadleaf weeds compared to their mixed use in the ratio of 1 : 4. Tank mix application of triasulfuron and sulfosulfuron in the ratio of 1 : 2 at 20 and 25 g ha^{-1} being at par with each other, was superior to its use in all other combinations against grassy weeds except triasulfuron+sulfosulfuron at 15 g ha^{-1} in the ratio of 1 : 2 during first year (Table 3). However, there was non-significant difference in the efficacy of triasulfuron+sulfosulfuron when used at various doses in two ratios during both the years except at its lowest dose in the ratio of 1 : 1 during 2001-02 only (Table 3). Similar to other three herbicides, tank mixture of triasulfuron and tralkoxydim at 250, 300 and 350 g ha^{-1} also resulted in increased reduction in the dry weight of grassy weeds with the corresponding increase in their doses. Tank mixture of these two herbicides at each dose was effective against grassy weeds when used in the ratio of 1 : 20 compared to 1 : 15, but reverse was true against broadleaf weeds (Table 4) In general, it appeared that toxicity due to tank mixed spray against complex weed flora was dose dependent and the ratio in their mixture that favoured more use rate of any alternate herbicide resulted in increased control of grassy weeds and decreased control of broadleaf weeds and vice-versa.

Effect on Yield

In general, the grain yield of wheat was more during 2001-02 compared to 2000-01 due to favourable weather conditions and early sowing during second year. Weeds growing throughout the crop season reduced grain yield of wheat to the extent of 23-34% during 2000-01 and 30-34% during 2001-02 (Tables 1, 2, 3 and 4). All the herbicides either used alone (except triasulfuron at 10 g ha^{-1} in experiments 1 and 2 in second year) or in combination resulted in significantly higher grain yield of wheat compared to weedy check (Tables 1, 2, 3 and 4). Clodinafop at 50 and 60 g ha^{-1} (Table 1), fenoxaprop at 100 and 120 g ha^{-1} (Table 2) and tralkoxydim at 300 and 350 g ha^{-1} (Table 4) being at par with each other were superior to their respective lower doses and inferior to the weed-free check. However, such differences were very narrow in case of sulfosulfuron (Table 3). Triasulfuron at 20, 40 and 60 g ha^{-1} being at par with each other resulted in significantly higher grain yield of wheat compared to its use at 10 g ha^{-1} (Tables 1, 2, 3 and 4). Alone application of any herbicide could not control the complex flora of weeds satisfactorily and consequently, resulted in significantly lower grain yield than weed-free check except sulfosulfuron at 20 and 25 g ha^{-1}. This might be due to effective control of both grassy as well as broadleaf weeds by sulfosulfuron. Malik *et al.* (2000) also reported similar response of sulfosulfuron under complex weed flora in wheat.

Among various herbicidal combinations, triasulfuron+clodinafop at 20+40 g and 24+36 g ha^{-1} (Table 1), triasulfuron+fenoxaprop at 24+96 g and 20+100 g ha^{-1} (Table 2), triasulfuron+ sulfosulfuron at 8.33+16.67 g ha^{-1} during both the years and 10+10 g ha^{-1} in 2000-01 (Table 3), and triasulfuron+ tralkoxydim at 21.8+328.2 g ha^{-1} and 16.6+333.4 g ha^{-1} (Table 4) could produce grain yield of wheat statistically equivalent to the plots kept weed-free throughout the crop season.

Based on present investigation, it can be argued that triasulfuron could be a strong candidate against broadleaf weeds in wheat. It can also work satisfactorily when used as tank mixture with any of the aforesaid alternate herbicides against complex weed flora in wheat dominated by wild oat. But future research would be required to study its efficacy in tank mix spray with these alternate herbicides against complex flora of weeds dominated by *P. minor* in rice-wheat rotation.

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