Indian Journal of Weed Science **45**(3): 210–213, 2013

Short communication

Evaluation of herbicides alone and in combination for weed control in wheat

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Received: 24 June2013; Revised: 11 September 2013

Wheat is the world's most widely cultivated food crop. Average yield losses due to weeds are 20-30%, however, heavy infestation of the formidable weeds can inflict huge crop losses (Singh *et al*. 1999). Grassy weeds like *Phalaris minor* and *Avena ludoviaciana* are dominant in rice-wheat rotation in north west plain zone. Continuous use of a particular herbicide may develop resistance in weeds. Herbicide mixtures may be an alternative for management or delay of cross resistance development against these herbicides (Dhawan *et al*. 2009). Keeping in view the above facts, the present investigation was undertaken to test the performance of herbicides alone or in combination to control weeds in wheat.

A field experiment was conducted during 2011-12 on research farm of CCS Haryana Agricultural university, Hisar situated is at 29^0 10'N latitude and 75^0 46' E longitudes with an elevation of 215.2 m above the mean sea level. The soil of the experimental field was sandy loam in texture with 210 t/ha available N, 15.6 kg/ha available P, 410 t/ha available K, 0.34% organic carbon and soil pH of 8.3. The experiment was done with 14 treatments (Table 1). Wheat was sown on 7th November 2011 with a row spacing of 20 cm in randomized block design with three replications. The herbicides were applied at 35 days after sowing using knapsack sprayer. In weed free treatment, weeds were removed as and when they appeared. The data on weeds was taken from 0.25 m^2 area. The data on crop growth parameters, yield attributes and yields were recorded as per standard parameters.

Among single herbicide application, metribuzin 210 g/ha resulted significantly lower population of *Phalaris minor* than application of clodinafop 60 g/ha, pinoxaden 40 g/ha and sulfosulfuron 25 g/ha because it controlled grassy weeds more efficiently. Singh *et al*. (2011) have also reported that metribuzin was effective in controlling grassy weeds in wheat. Among various combinations, the population of *P. minor* was minimum in sulfosulfuron + metribuzin 25 + 210 g/ha which might be due to synergistic effect of these herbicides in controlling grassy weeds particularly *P. minor*. Application of sulfosulfuron + metsulfuron 32 g/ha resulted in significantly lower plant population of *Phalaris minor* because of combined effect of sulsufuron + metsulfuron. Isoproturon + 2,4-D (1000 + 500 g/ha) application resulted in more number of *P. minor* plant as compared to other mixed herbicides application which might be due to resistance of *P. minor* to isoproturon (Table 1). Resistance of *P. minor* to isoproturon has already been established and reported by Malik and Singh (1995).

Initially up to 30 DAS, no significant difference in population of *Chenopodium album* was recorded because no herbicide treatments were imposed in different plots of the experiment. At 60 and 90 DAS, application of metribuzin 210 g/ha and sulfosulfuron 25 g/ha resulted in significantly less plant population of *Chenopodium album* than clodinafop 60g/ha and pinoxaden 40 g/ha (Table 2). Singh *et al*. (2005) also reported that alone application of sulfosulfuron 25 g/ha or metribuzin 210 g/ha provided reduction in density of broadleaf weeds. Application of sulfouslfuron + metribuzin 25 + 210 g/ha resulted in lower plant population of *C. album* at 60, 90, 120 DAS and at maturity which may be due to more control of broadleaf weeds by sulfosulfuron 25 g/ha and metribuzin 210 g/ha. These results are in conformity with Sharma (2012).

Weed control efficiency (WCE) was significantly higher with application of sulfosulfuron 25 g/ha among single application of herbicides. This may be due to better control of *C. album* (Table 3) which led to less dry matter accumulation by weeds. Application of sulfosulfuron + metsulfuron 32 g/ha resulted in 89.2% WCE which was at par with sulfosulfuron+metribuzin 25 + 210 g/ha may be due to more control of grassy and broadleaf weeds.

Number of spikes in single applied herbicides were not influenced significantly, however, sulfosulfuron applied 25 g/ha produced the higher number of spike which may be due to the better control of weeds by this herbicides as compared to metribuzin 210 g/ha, clodinafop 60 g/ha and pinoxaden 40 g/ha as evident from the lower weeds dry matter (Table 3) in this herbicide. Application of metribuzin 210 g/ha in combination with clodinafop 60

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g/ha, sulfosulfuron 25 g/ha and fenoxaprop 120 g/ha produced more number of spikes as compared to its alone application which was attributed to the superior control of weeds in herbicide mixtures as evident from the better weed control efficiency of herbicide mixtures. The positive effect of herbicide mixtures in controlling complex weed flora have also been reported by Singh *et al*. (2005).

Different herbicide treatments resulted in significantly higher 1000-grain weight as compared to weedy check but at par with weed free. This may be due to less competition for different resources in herbicide treatments being efficient in controlling weeds which resulted in more translocation of food from source to sink. Similar result had also been reported by Singh *et al*. (2012).

Herbicide mixture of metribuzin 210 g/ha with clodinafop 60 g/ha, pinoxaden 40 g/ha, sulfosulfuron 25 g/ha and fenoxaprop 120 g/ha resulted more straw yield of wheat, as compared to the alone application of metribuzin 210 g/ha. Application of mixed herbicides produced similar straw yield as compared to weed free. This may be due to non-significant difference in dry matter accumulation by wheat in herbicide mixture which resulted in non-significant different in straw yield.

Weed control treatments produced significantly higher grain yield as compared to weedy check. Sulfosulfuron 25 g/ha being significantly superior to alone application of metribuzin 210 g/ha, clodinafop 60 g/ha and pinoxaden 40 g/ha produced higher wheat grain yield,

Table 1. Effect of different weed control treatments on population (no./m²) of *Phalaris minor* in wheat

Treatment	Dose (g/ha)	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Metribuzin	210	6.3(38.6)	1.8(2.3)	1.6(1.7)	1.5(1.4)	1.3(0.7)
Clodinafop	60	6.1(35.6)	3.3(2.3)	2.4(1.7)	1.9(10.7)	1.7(4.3)
Pinoxaden	40	6.2(37.3)	3.5(2.7)	2.4(1.3)	1.9(11.0)	1.7(4.7)
Sulfosulfuron	25	6.1(36.6)	4.3(18.0)	3.5(11.7)	2.9(7.7)	2.4(4.7)
Clodinafop + metribuzin	60+210	6.2(37.6)	2.9(7.3)	2.1(3.4)	1.8(2.4)	1.6(1.7)
Pinoxaden + metribuzin	40+210	6.0(35.0)	2.7(6.3)	2.1(3.4)	1.8(2.4)	1.6(1.7)
Sulfosulfuron + metribuzin	25+210	6.2(37.6)	2.2(3.6)	1.8(2.4)	1.3(1.0)	1.3(0.7)
Fenoxaprop + metribuzin	120+210	5.8(33.3)	2.6(6.0)	1.9(2.7)	1.6(1.7)	1.5(1.3)
Sulfosulfuron + metsulfuron	32	6.0(35.3)	2.1(3.4)	1.6(1.7)	1.3(0.7)	1.1(0.3)
Mesosulfuron + iodosulfuron	14.4	6.0(35.0)	2.2(4.0)	1.8(2.4)	1.6(1.7)	1.5(1.3)
Clodinafop + metsulfuron	60+4	6.4(40.3)	2.1(3.4)	1.7(2.0)	1.6(1.7)	1.5(1.3)
Isoproturon + 2,4-D	1000+500	6.2(38.0)	4.6(7.3)	3.5(4.7)	2.9(20.0)	2.4(11.3)
Weedy check		6.4(40.3)	5.7(32.0)	5.1(26.0)	4.9(23.6)	4.5(20.0)
Weed free		1.0(0.00)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)
LSD (P=0.05)		0.3	0.21	0.21	0.35	0.30

DAS - Days after sowing; Original data given in parentheses

Table 2. Effect on different weed control treatments on population (no./m²) of *Chenopodium album* in wheat

Treatment	Dose (g/ha)	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Metribuzin	210	7.1(50.0)	2.9(18.7)	2.2(15.7)	1.8(8.0)	1.5(3.7)
Clodinafop	60	6.8(44.7)	5.4(28.0)	4.7(21.4)	4.2(17.4)	4.1(15.7)
Pinoxaden	40	6.9(47.7)	5.3(27.6)	4.6(20.7)	4.3(17.7)	4.0(15.3)
Sulfosulfuron	25	6.8(43.7)	2.9(2.3)	2.1(1.7)	1.8(7.3)	1.5(3.3)
Clodinafop + metribuzin	60+210	7.1(48.7)	2.6(1.70	1.8(0.7)	1.6(5.7)	1.3(2.3)
Pinoxaden + metribuzin	40+210	6.8(44.7)	2.1(1.3)	1.6(0.7)	1.5(3.3)	1.3(1.7)
Sulfosulfuron + metribuzin	25+210	6.6(42.7)	2.1(1.0)	1.5(0.3)	1.4(3.3)	1.1(1.3)
Fenoxaprop + metribuzin	120+210	6.8(45.6)	2.9(1.7)	2.1(1.3)	1.6(7.3)	1.5(3.3)
Sulfosulfuron + metsulfuron	32	6.6(42.0)	2.2(1.3)	1.6(0.7)	1.5(3.7)	1.3(1.7)
Mesosulfuron + iodosulfuron	14.4	6.7(43.3)	3.1(1.7)	2.1(1.0)	1.6(8.3)	1.4(3.3)
Clodinafop + metsulfuron	60+4	6.7(43.7)	2.3(4.4)	1.6(1.7)	1.5(1.4)	1.4(1.0)
Isoproturon + 2,4-D	1000+500	7.1(49.3)	3.5(2.7)	2.5(1.7)	1.9(11.3)	1.6(5.3)
Weedy check		7.1(50.0)	6.7(30.7)	6.3(28.0)	5.6(44.3)	5.4(38.6)
Weed free		1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)
LSD (P=0.05)		0.32	0.29	0.23	0.19	0.18

DAS - Days after sowing, Original data given in parentheses was subjected to square root $\sqrt{(x+1)}$ tansformation before analysis

Table 3. Effect of different weed control treatments on dry matter of *C. album* at different crop stages and weed control efficiency

Treatment	Dose (g/ha)	Dry matter (g/m^2)					Weed control efficiency (%)
		30 DAS	60 DAS	90 DAS	120 DAS	At maturity	
Metribuzin	210	4.0	17.8	28.1	43.3	47.8	70.5
Clodinafop	60	3.5	21.8	35.3	62.3	66.4	59.9
Pinoxaden	40	4.0	20.9	33.2	59.8	63.3	61.8
Sulfosulfuron	25	3.4	14.3	22.2	35.7	40.4	76.4
Clodinafop + metribuzin	60+210	4.1	8.4	12.4	20.5	28.3	82.9
Pinoxaden + metribuzin	40+210	3.9	7.8	10.3	18.2	26.1	84.2
Sulfosulfuron + metribuzin	25+210	3.8	6.2	9.5	17.1	23.3	85.9
Fenoxaprop + metribuzin	120+210	3.5	9.3	14.4	23.3	26.2	84.1
Sulfosulfuron + metsulfuron	32	3.8	6.0	8.3	14.4	17.7	89.2
Mesosulfuron + iodosulfuron	14.4	3.9	9.0	12.8	22.6	25.4	84.6
Clodinafop + metsulfuron	60+4	3.8	9.9	17.4	26.3	29.4	82.2
Isoproturon + 2,4-D	1000+500	3.4	9.6	15.3	25.3	28.3	82.9
Weedy check		3.8	45.2	85.6	134.5	166.5	0.0
Weed free		0.0	0.0	0.0	0.0	0.0	100.0
LSD (P=0.05)		NS	5.5	5.9	8.1	7.4	3.79

DAS - Days after sowing

Table 4 . Effects of different weed control treatments on yield attributes and yield of wheat

Treatment	Dose (g/ha)	Spikes/m^2	Grains/ spikes	1000-grain wt.(g)	Straw yield (t/ha)	Grain yield (t/ha)	HI (%)
Metribuzin	210	383	33.8	41.1	8.13	5.34	39.7
Clodinafop	60	376	32.5	41.6	7.73	5.08	39.7
Pinoxaden	40	378	34.2	41.1	7.70	5.19	40.3
Sulfosulfuron	25	402	34.1	41.5	8.33	5.70	40.7
Clodinafop + metribuzin	60+210	440	33.9	41.9	9.0	6.24	40.9
Pinoxaden + metribuzin	40+210	443	34.3	41.6	9.08	6.32	41.1
Sulfosulfuron + metribuzin	25+210	450	34.0	41.9	9.12	6.41	41.3
Fenoxaprop + metribuzin	120+210	432	34.0	41.8	9.07	6.16	40.5
Sulfosulfuron + metsulfuron	32	452	33.8	42.0	9.04	6.42	41.5
Mesosulfuron + iodosulfuron	14.4	435	34.0	41.9	8.91	6.19	41.0
Clodinafop + metsulfuron	60+4	422	34.6	41.3	8.75	6.04	40.8
Isoproturon + 2,4-D	1000+500	425	34.3	41.6	8.78	6.07	40.9
Weedy check		332	31.9	39.0	6.44	4.14	39.2
Weed free		453	33.8	42.2	9.03	6.46	41.7
LSD (P=0.05)		44	2.7	2.0	1.15	0.59	NS

which may be due to the better weed control as is evident from the higher WCE *i.e.* 76.4 as compared to other herbicides. Moreover, the number of spikes in this treatment was higher than metribuzin 210 g/ha, clodinafop 60 g/ha and pinoxaden 40 g/ha, which attributed to the higher yield in this treatment.

Ready mix application of sulfosulfuron + metsulfuron 32 g/ha produced the highest grain yield (6.42 t/ha) among different herbicide treatments but it was statistically at par with weedy free. Non-significant differences in number of spikes, grain number and 1000 grain weight of ready mix herbicides lead to non-significant variation in grain yield of wheat. Moreover, rapid growth of wheat plant efficiently utilized the resources in absence of weeds.

SUMMARY

Metribuzin alone 210 g/ha resulted in significantly lower population of *Phalaris minor* than alone application of clodinafop 60 g/ha, pinoxaden 40 g/ha and sulfosulfuron 25 g/ha. Application of sulfosulfuron + metsulfuron 32 g/ha and 25 + 210 g/ha resulted in significantly lower population of *P. minor* and *C. album*, respectively. Sulfosulfuron + metsulfuron 32 g/ha resulted

in 89.2% WCE which was at par with sulfosulfuron + metribuzin 25 + 210 g/ha. Weed control treatments produced significantly higher grain yield as compared to weedy check. Sulfosulfuron 25 g/ha being significantly superior to alone application of metribuzin 210 g/ha, clodinafop 60 g/ha and pinoxaden 40 g/ha produced higher wheat grain yield, which was evident from the higher WCE as compared to other herbicides. Ready-mix application of sulfosulfuron + metsulfuron at 32 g/ha produced the highest grain yield (6.42 t/ha) among different herbicide treatments but it was statistically at par with weed free.

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