Indian Journal of Weed Science **52**(1): 32–36, 2020

Print ISSN 0253-8040 Online ISSN 0974-8164

Herbicide options for weed management in sugarcane + wheat intercropping system in Indo-Gangetic Plains

Dharam Bir Yadav*, Mehar Chand, B.R. Kamboj, Ashok Yadav and S.S. Punia
CCS Haryana Agricultural University, Hisar, Haryana 125 004, India
**Email: dbyadav@gmail.com*

Article information

DOI: 10.5958/0974-8164.2020.00005.2

Type of article: Research article

Received : 17 August 2019
Revised : 13 December 2019
Accepted : 15 December 2019

Key words
Sugarcane + wheat
Intercropping
Herbicides
Phalaris minor
Weed control
Phyto-toxicity

ABSTRACT

Field and farmer participatory trials were conducted from 2006-07 to 2012-13 to evaluate the efficacy of herbicides alone and in combination on complex weed flora in sugarcane + wheat intercropping system. Sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha, pinoxaden 50 g/ha, pinoxaden + metsulfuron 50 + 4 g/ha, pinoxaden + 2,4-D 50 + 500 g/ha, pinoxaden *fb* carfentrazone 50 *fb* 20 g/ha gave satisfactory control of *Phalaris minor*. However, pinoxaden treatments were superior to other herbicides in respect of grassy weed management. For control of broad-leaf weeds, tank-mix of metsulfuron or 2,4-D with pinoxaden were found effective. Ready-mix herbicides sulfosulfuron+ metsulfuron and mesosulfuron+ iodosulfuron were also found promising against complex weed flora in sugarcane + wheat intercropping system. Clodinafop 60 g/ha, fenoxaprop 100 g/ha and carfentrazone 20 g/ha were phyto-toxic to the sugarcane. Grain yields of wheat under sulfosulfuron, sulfosulfuron + metsulfuron (ready-mix), mesosulfuron + iodosulfuron (ready-mix), pinoxaden alone and in combination with metsulfuron, 2,4-D or carfentrazone were as good as weed free check. Similarly the cane yields under these treatments except pinoxaden *fb* carfentrazone and sulfosulfuron + metsulfuron (ready-mix) were at par with each other and also with weed free check. Sulfosulfuron 25 g/ha, sulfosulfuron+ metsulfuron (ready-mix) 32 g/ha, mesosulfuron+ iodosulfuron (ready-mix) 14.4 g/ha or pinoxaden 50 g/ha provided effective control (83-97%) of weeds including *Phalaris minor* over the years. These treatments provided higher grain yield of wheat (4.65-4.93 t/ha) and cane yield (85.5-91.1 t/ha) of sugarcane.

INTRODUCTION

Sugarcane is planted in autumn (September-October), spring (February-March) and summer (April-May) seasons in Indo-Gangetic Plains. Autumn planting provides longer time for germination as well as tillering as compared to spring and summer plantings. When sugarcane planting is delayed from February to April/May, it gets lesser time for tillering and reduces productivity (Pandey and Shukla 2001). Hence, the autumn sugarcane yields 25-30% more than spring cane and 40-50% more than the summer planted crop (Rana *et al*. 2006 and Singh *et al*. 1990). Autumn sugarcane is considered more congenial for intercropping of winter season crops as low temperature regime causes slow growth of sugarcane (Singh *et al*. 1999). But the area under autumn planted sugarcane is limited as the profitability from sole sugarcane is less than the two crops (*Rabi* crop *fb* summer season sugarcane). Moreover, many farmers, who do not want to sacrifice *Rabi* crop at the cost of autumn cane; this could be compensated by raising intercrops in between the rows of sugarcane during early 4-5 months leading to efficient utilization of resources. Intercropping systems of sugarcane with wheat, raya, peas, rapeseed, barley and gram were more profitable than sole sugarcane (Singh *et al*. 2007). Wheat is an important crop of this zone, which is staple food crop with assured market and plays a major role in food security of the country. Sugarcane can be successfully grown in intercropping system with wheat under furrow irrigated raised beds (FIRB) (Kamboj *et al*. 2008, IISR 2017). Wheat can be sown on beds and sugarcane in the furrows during the last week of October. The performance of this system is quite good and has been recommended by the state University in Haryana.

Autumn sugarcane remains in the field for a year or more and the space between sugarcane rows (90 cm) provide ample chance for profuse weed growth which draws huge amount of nutrients and moisture from the soil and thus reduce the cane yields. Yield losses due to the presence of weeds (in sole sugarcane/ intercropping system) were estimated to the tune of 26-75% (Patil *et al.* 1991; Srivastav *et al.* 2005). Conventional method of hand hoeing or inter culture is not feasible in intercropping systems. This discourages the farmers to adopt intercropping in sugarcane. These concerns necessitated the use of herbicides for timely and effective control of weeds as well as an economic alternative to the costly labour (Bhullar *et al.* 2006). In inter-cropping system, there is a need for evaluation of herbicides alone or in combination for control of the complex weed flora for making system based recommendations. Hence, the present investigation was undertaken to identify the effective herbicidal options (particularly post-emergence) for weed control in sugarcane+ wheat intercropping system.

MATERIALS AND METHODS

Experiment 1

The phyto-toxicity evaluation trial was conducted at CCS HAU Regional Research Station, Karnal, Haryana during 2006-07 using herbicides used in wheat clodinafop 60 g/ha, sulfosulfuron 25 g/ha and fenoxaprop 100 g/ha. The treatments were randomly arranged in three replications. The field was slightly alkaline in reaction (pH=8.3), low in organic carbon (0.34%), medium in phosphorus (12 kg P_2O_5/ ha) and potash (227 kg K_2O/ha). Sowing of sugarcane and wheat intercrop was done on 25 October, 2006. During 2007-08, phyto-toxicity evaluation of sulfosulfuron 25 g/ha, sulfosulfuron+ metsulfuron (ready-mix) 32 g/ha, pinoxaden 50 g/ha, mesosulfuron+ iodosulfuron 14.4 g/ha was done at village Khanpur, Yamuna Nagar. The plot size was 10.0 x 3.6 m and the treatments were randomly arranged in three replications. Sowing of sugarcane and wheat crops was done on 22 October, 2007. The field was slightly alkaline in reaction (pH=8.0), low in organic carbon (0.38%), medium in phosphorus (16 kg P_2O_5/ha) and potash (245 kg K_2O/ha). The observations on crop phytotoxicity (chlorosis, necrosis, stunting, epinasty, hyponasty and wilting) on a 0-10 scale (0-no phyto-toxicity and 10-complete phyto-toxicity) were recorded at 30, 60 and 90 days after treatment application during both the years.

Experiment 2

Based on findings of Experiment 1, a field experiment was laid out at CCS Haryana Agricultural University, Regional Research Station, Karnal to evaluate the herbicides for control of weeds in sugarcane+ wheat intercropping system. The soil of the experimental plots was clay loam in texture, low in organic carbon (0.32-0.34%), medium in phosphorus (12-14 kg P_2O_5/ha) and potash (224-232 kg K_2O/ha) with slightly alkaline pH (pH=8.2-8.4). The treatments included pendimethalin 1000 g/ha, isoproturon 1000 g/ha, sulfosulfuron 25 g/ha, sulfosulfuron+ metsulfuron (ready-mix) 32 g/ha, mesosulfuron+ iodosulfuron (ready-mix) 14.4 g/ha, pinoxaden 50 g/ha, pinoxaden+ 2,4-D 50 + 500 g/ha, pinoxaden + metsulfuron 50 + 4 g/ha, pinoxaden 50 g/ha *fb* carfentrazone 20 g/ha, along with weed free and weedy checks. The treatments were laid out in randomized block design with three replicates during 2008-09 and 2009-10. Sowing was done on 25th October 2008 by adopting furrow irrigated raised bed method (90 cm = 55 cm top, 35 cm furrow) during 2008-09 and on 30th October by wide bed and furrow method (135 cm = 90 cm top, 45 cm furrow) during 2009-10 with wheat cultivar '*DBW 17*' sown on beds and sugarcane cultivar '*CoH-136*' planted in the furrows. Seed rate used was 112.5 kg/ha for wheat and 8.75 t/ha for sugarcane. Three rows (18 cm spacing) and four rows (22 cm) of wheat were sown per bed, making a 54:18:18 cm and 69:22:22:22 cm crop geometry during 2008-09 and 2009-10, respectively. During 2008-09, the row to row spacing for sugarcane was 90 cm, while during 2009-10, two rows of sugarcane were planted (35 cm spacing) in each furrow (furrow spacing of 135 cm), in a 100:35 cm crop geometry for sugarcane. Crops were raised according to package of practices of the state University. Observations on weeds were recorded at 90 days after sowing (DAS). Crop yield and yield parameters were recorded at maturity of respective crops. Harvesting of wheat was done on 5th April, 2009 and 20th April, 2010 and sugarcane on 26th October, 2009 and 2nd November, 2010 during 2008-09 and 2009-10 seasons, respectively.

Experiment 3

Some of the herbicidal options found suitable in the experiments at research farm for weed control in sugarcane + wheat intercropping system, were also evaluated at farmers' field situations in farmer-participatory trials as well during 2010-11, 2011-12 and 2012-13, with nine, eight and seven locations, respectively. The treatments included sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha and pinoxaden 50 g/ha along with weed free and weedy checks. The experiment was laid out in randomized block design with number of locations serving as number of replications.

Sowing of crops was done on 25-31 October 2010, 26-31 October 2011 and 26-30 October 2012 during 2010-11, 2011-12 and 2012-13 crop seasons, respectively, using a seed rate of 100 kg/ha for wheat and 7.0-8.5 t/ha for sugarcane. Sugarcane was sown at a spacing of 90 cm and three rows of wheat were sown in between with a row spacing of 18 cm. The plot size was 600 m^2. The herbicides were applied as spray in a spray volume of 500 liter water per hectare, with knapsack sprayer using flat-fan nozzle. Data on percent weed control was recorded at 75 DAS. Wheat crop was harvested on 14-21 April during different years. For recording grain yield of the crop, two samples from an area of 5.0 x 5.0 m in each plot were harvested. The data on cane yield were recorded at harvest of the crop. Harvesting of sugarcane was done on 10-31 December. For recording cane yield, two samples from an area 9 x 10 m in each plot were harvested.

RESULTS AND DISCUSSION

Experiment 1

The phyto-toxicity studies during 2006-07 and 2007-08 indicated that among wheat herbicides, clodinafop 60 g/ha and fenoxaprop 120 g/ha resulted in phyto-toxicity on the sugarcane crop (4.0 and 4.8 on 10 point scale at 30 days after treatment (DAT), which progressed further with time (6.3 and 7.0 at 60 DAT, respectively) leading to almost complete toxicity (8.8 and 9.3 at 90 DAT, respectively). Other herbicides (sulfosulfuron, sulfosulfuron + metsulfuron, pinoxaden and metsulfuron + iodosulfuron) were found to be safe to sugarcane (data not given).

Experiment 2

The field was infested mainly with *Phalaris minor* among grassy weeds, *Coronopus didymus, Anagallis arvensis, Vicia sativa* and *Rumex dentatus* among broad-leaf weeds and *Cyperus rotundus* among sedges.

Sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron 14.4 g/ha, pinoxaden 50 g/ha, pinoxaden + metsulfuron 50 + 4 g/ha, pinoxaden + 2,4-D 50 + 500 g/ha provided effective control of weed grassy weed *Phalaris minor,* as evidenced by reduction in grassy weeds density and biomass by these herbicides during both the years (**Table 1**). These treatments resulted in *P. minor* biomass reduction (0.0-8.4 g/m^2 in 2008-09 and 2.2-12.9 g/m^2 in 2009-10) as low as weed free check during both the years; however, pinoxaden treatments were superior to other herbicidal treatments in respect of density (0.0-2.7/m^2) and were at par with weed free checks during 2008-09. All these treatments were superior to pendimethalin or isoproturon in respect of density and biomass of grassy weeds; however, pendimethalin was superior to isoproturon against *P. minor*. Efficacy of sulfosulfuron, sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron, pinoxaden, metsulfuron-methyl and 2,4-D at a dose already recommended to wheat crop as post-emergence herbicides for weed control in sugarcane+ wheat system was reported by other workers as well (Kamboj *et al*. 2008, Kumar *et al*. 2017). Other workers have reported that pendimethalin (IISR, 2017) and isoproturon (Fahad *et al*. 2013) could be used for control of weeds in sugarcane + wheat intercropping system.

Sulfosulfuron + metsulfuron (ready-mix), mesosulfuron + iodosulfuron (ready-mix), and tank-mix of metsulfuron or 2,4-D with pinoxaden provided excellent control of broad-leaf weeds also as evidenced from weed density (38.0-76.0/m^2 in 2008-09 and 1.3-12.7/m^2 in 2009-10) and biomass (12.9-23.6 g/m^2 in 2008-09 and 0.5-4.0 g/m^2 in 2009-10), which were superior to pinoxaden or sulfosulfuron alone. Isoproturon or pendimethalin were also effective against broad-leaf weeds and pendimethalin (4.3-30.0 g/m^2) had an edge over isoproturon (10.6-33.5 g/m^2). Sulfosulfuron+ metsulfuron (ready-mix) or pinoxaden + 2,4-D also significantly suppressed the sedges, while other herbicides were not effective against sedges (*Cyperus rotundus*) except little suppression by sulfosulfuron. 2,4-D was the best option against sedges. Carfentrazone 20 g/ha in sequence with pinoxaden 50 g/ha provided good control of grass and broad-leaf weeds (**Table 1**) but was phyto-toxic to the sugarcane crop with necrotic red spots appearing on the leaves (**Table 3**). All the other herbicide treatments were safe to both the crops. However, slight phyto-toxicity (1.2 on 0-10 scale) of sulfosulfuron+ metsulfuron (ready-mix) was observed on sugarcane at later stages during 2009-10, but it did not have any adverse effect on sugarcane yield. There was little phyto-toxicity of mesosulfuron + iodosulfuron and carfentrazone on wheat (0.1-0.2 on 0-10 scale) during 2008-09 but it recovered very shortly (**Table 2**).

Plant height and ear head length of wheat were not influenced by different treatments, except during 2008-09 when lowest plant height was recorded under pendimethalin, isoproturon and weedy check (**Table 2**). Similarly cane height and cane girth were not influenced by different treatments (**Table 3**). Number of effective tillers (104.3-109.5/mrl in 2008-09 and 105.9-113.7/mrl in 2009-10) and grain yield (5.64-6.05 t/ha in 2008-09 and 3.52-3.82 t/ha in 2009-10) of wheat under sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha, pinoxaden 50 g/ha, pinoxaden + metsulfuron 50 + 4 g/ha, pinoxaden + 2,4-D 50 + 500 g/ha, pinoxaden 50 g/ha *fb* carfentrazone 20 g/ha were at par with weed free check (112.7/mrl and 6.08 t/ha in 2008-09; 115.7/mrl and 3.86 t/ha in 2009-10, respectively) during both the years (**Table 2**). Similarly, number of millable canes and cane yield (81.6-88.5 t/ha in 2008-09 and 85.0-96.7 t/ha) under these treatments except pinoxaden *fb* carfentrazone were at par with weed free check (89.9 and 100.7 t/ha, respectively) except sulfosulfuron + metsulfuron (ready-mix) being inferior during 2009-10 (**Table 3**). Pinoxaden *fb* carfentrazone gave the lowest yield (62.0 t/ha) of sugarcane among all the herbicidal treatments during 2008-09 and was even lower than pendimethalin or isoproturon (71.1-76.1 t/ha); however, these three treatments were at par with each other during 2009-10 (72.1-84.3 t/ha). Pendimethalin 1000 g/ha was superior to isoproturon 1000 g/ha in controlling weeds (**Table 1**), however, the differences in respect of crop yields were not always significant (**Table 2** and **3**).

Experiment 3

The farmer-participatory trials during 2010-11 to 2012-13 indicated that sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha or pinoxaden 50 g/ha provided effective control (83-97% control of weeds including *P. minor* over the years) in sugarcane + wheat intercropping system (**Table 4**). These treatments provided grain yields of wheat (4.52-4.93 t/ha) and cane yield (82.7-91.1 t/ha) of sugarcane at par with each other and also the weed free check (4.90-5.04 t/ha of wheat and 87.7-91.7 t/ha of sugarcane) during all the seasons, except sulfosulfuron 25 g/ha during 2011-12 being inferior to pinoxaden 50 g/ha in respect of grain yield of wheat. Earlier reports have also established suitability of sulfosulfuron, sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron, and pinoxaden as PoE herbicides for weed control in sugarcane + wheat inter-cropping system (Kamboj *et al.* 2008, Kumar *et al.* 2017).

Table 1. Effect of different weed control treatments on weed density and biomass in sugarcane + wheat intercropping system (2008-09 and 2009-10)

Treatment	Dose (g/ha)	Time (DAS)	Weeds density (no./m^2)*					Weeds biomass (g/m^2)				
			Phalaris minor		Broad-leaf weeds		Sedges	Grassy weeds		Broad-leaf weeds		Sedges
			08-09	09-10	08-09	09-10	08-09	08-09	09-10	08-09	09-10	08-09
Pendimethalin	1000	0-3	3.4(10.7)	5.6(30.0)	4.3(17.3)	2.3(5.3)	6.9(46.7)	36.0	40.2	30.3	4.3	5.1
Isoproturon	1000	35	4.0(14.7)	7.8(60.0)	6.7(44.0)	3.8(14.0)	7.7(59.3)	57.6	149.8	33.5	10.6	8.1
Sulfosulfuron	25	35	2.3(4.7)	2.6(6.0)	10.6(112.0)	5.6(30.0)	6.0(35.3)	12.2	5.4	41.8	15.5	7.4
Sulfosulfuron + metsulfuron (RM)	32	35	2.2(4.0)	3.5(11.3)	7.0(48.0)	2.8(6.7)	5.1(25.3)	7.9	8.9	13.1	4.0	4.8
Mesosulfuron + iodosulfuron (RM)	14	35	2.5(5.3)	4.2(18.0)	8.8(76.0)	1.4(1.3)	6.9(47.3)	8.4	12.9	23.6	0.5	5.3
Pinoxaden	50	35	1.0(0.0)	2.5(5.3)	11.3(126.7)	6.2(37.3)	7.5(56.0)	0.0	2.2	66.0	21.4	9.5
Pinoxaden + 2,4-D	50+500	35	1.4(1.3)	3.3(10.0)	6.7(44.7)	3.6(12.7)	3.6(12.0)	0.2	7.6	17.1	3.7	1.3
Pinoxaden + metsulfuron	50+4	35	1.8(2.7)	3.4(10.7)	6.2(38.0)	2.2(4.7)	7.1(50.7)	3.5	7.6	12.9	3.2	6.3
Pinoxaden *fb* carfentrazone	50 *fb* 20	35 *fb* 42	1.5(1.3)	4.2(16.7)	5.9(33.3)	4.2(17.3)	6.5(42.0)	3.1	12.2	20.9	11.5	6.7
Weed free			1.0 (0)	1.0(0)	1.0(0)	1.0(0)	1.0(0)	0	0	0	0	0
Weedy check			6.6(43.3)	10.0(98.7)	12.0(142.0)	5.9(34.0)	6.5(41.3)	116.1	199.5	76.3	29.7	6.5
LSD (p=0.05)			0.63	0.88	0.67	1.43	1.16	8.9	15.3	12.2	5.0	2.2

*Original figures in parentheses were subjected to square root transformation ($\sin^{-1}\sqrt{X}$) before statistical analysis. RM, ready-mix; DAS, days after sowing; LSD, least significant difference; *fb*, followed by

Table 2. Effect of different weed control treatments on yield and yield attributes of wheat in sugarcane + wheat intercropping system (2008-09 and 2009-10)

Treatment	Dose (g/ha)	Time (DAS)	Plant height (cm)		Effective tillers/mrl		Ear head length (cm)		Grain yield (t/ha)		Phyto-toxicity (0-10 scale)	
			08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10
Pendimethalin	1000	0-3	83.5	85.5	93.6	103.0	9.6	9.7	5.17	3.28	0.0	0.0
Isoproturon	1000	35	83.6	86.8	87.4	92.3	9.6	9.5	4.92	2.95	0.0	0.0
Sulfosulfuron	25	35	84.3	86.8	104.3	105.9	9.7	9.9	5.64	3.60	0.0	0.0
Sulfosulfuron + metsulfuron (RM)	32	35	84.1	86.9	107.3	106.7	9.8	9.9	5.77	3.61	0.0	0.0
Mesosulfuron + iodosulfuron (RM)	14	35	84.3	85.1	109.5	108.1	9.7	9.9	5.78	3.52	0.1	0.0
Pinoxaden	50	35	84.5	86.4	106.4	113.7	9.7	10.1	5.78	3.74	0.0	0.0
Pinoxaden + 2,4-D	50 + 500	35	85.0	87.7	108.5	111.7	9.8	9.8	5.88	3.75	0.0	0.0
Pinoxaden + metsulfuron	50 + 4	35	84.3	87.3	109.5	113.2	9.8	10.0	6.05	3.82	0.0	0.0
Pinoxaden *fb* carfentrazone	50 *fb* 20	35 *fb* 42	84.1	86.7	107.3	107.7	9.8	10.1	5.92	3.70	0.2	0.0
Weed free			85.3	86.9	112.7	115.7	10.1	10.1	6.08	3.86	0.0	0.0
Weedy check			82.4	84.0	78.6	75.7	9.5	9.5	3.21	2.18	0.0	0.0
LSD (p=0.05)			1.2	NS	8.5	7.6	NS	NS	0.47	0.27		

DAS, days after sowing; mrl, meter row length; RM, ready-mix; NS, non-significant, LSD, least significant difference; *fb,* followed by

Table 3. Effect of different weed control treatments on growth and yield of sugarcane in sugarcane+ wheat intercropping system (2008-09 and 2009-10)

Treatment	Dose (g/ha)	Time (DAS)	Cane height (cm)		Millable canes (000/ha)		Cane girth (cm)		Cane yield (t/ha)		Phyto-toxicity (0-10 scale)			
											08-09		09-10	
			08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	45 DAT	90 DAT	45 DAT	90 DAT
Pendimethalin	1000	0-3	201	210	78.5	82.2	2.0	2.2	76.1	80.6	0.0	0.0	0.0	0.0
Isoproturon	1000	35	192	201	75.3	76.6	2.0	2.1	71.1	72.1	0.0	0.0	0.0	0.0
Sulfosulfuron	25	35	205	214	84.6	89.9	2.2	2.3	82.0	90.6	0.0	0.0	0.0	0.4
Sulfosulfuron + metsulfuron (RM)	32	35	210	217	87.1	86.6	2.3	2.2	87.6	85.0	0.0	0.0	0.0	1.2
Mesosulfuron + iodosulfuron (RM)	14	35	208	216	83.5	88.3	2.2	2.3	81.6	88.3	0.0	0.0	0.0	0.2
Pinoxaden	50	35	208	218	85.8	90.0	2.3	2.3	83.0	92.6	0.0	0.0	0.0	0.0
Pinoxaden + 2,4-D	50 + 500	35	209	218	86.3	90.9	2.3	2.3	85.5	95.9	0.0	0.0	0.0	0.0
Pinoxaden + metsulfuron	50 + 4	35	210	220	88.6	91.0	2.3	2.4	88.5	96.7	0.0	0.0	0.0	0.0
Pinoxaden *fb* carfentrazone	50 *fb* 20	35 *fb* 42	194	202	72.2	84.6	2.1	2.2	62.0	84.3	2.0	1.0	2.5	0.3
Weed free			210	222	89.4	92.2	2.4	2.5	89.9	100.7	0.0	0.0	0.0	0.0
Weedy check			192	200	60.3	71.7	1.9	1.9	40.9	66.1	0.0	0.0	0.0	0.0
LSD (p=0.05)			NS	NS	5.2	4.6	NS	NS	8.4	13.7				

DAT, days after treatment; DAS, days after sowing; RM, ready-mix; NS, non-significant; LSD, least significant difference; *fb,* followed by

Table 4. Effect of different treatments on weeds control in sugarcane+ wheat intercropping system, and its effect on grain yield of wheat and cane yield in farmer participatory trials in Haryana (2010-11 to 2012-13)

Treatment	Dose (g/ha)	Time (DAS)	Weed control (%)*			Grain yield of wheat (t/ha)			Cane yield (t/ha)		
			2010-11	2011-12	2012-13	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
Sulfosulfuron	25	35	73.1(90.6)	65.7(82.8)	68.2(85.8)	4.52	4.56	4.70	87.7	82.7	87.3
Sulfosulfuron+ metsulfuron (RM)	32	35	76.7(93.6)	70.8(88.8)	73.1(91.0)	4.82	4.79	4.76	89.7	85.5	88.9
Mesosulfuron+ iodosulfuron (RM)	14.4	35	74.4(91.5)	72.9(90.8)	72.0(90.0)	4.78	4.85	4.72	88.8	85.6	89.5
Pinoxaden	50	35	81.3(96.9)	76.6(94.3)	80.8(96.5)	4.88	4.93	4.88	90.8	86.8	91.1
Weed free			90.0(100.0)	90.0(100.0)	90.0(100.0)	4.90	5.04	4.93	91.5	87.7	91.7
Weedy check			0.0(0.0)	0.0(0.0)	0.0(0.0)	2.78	3.00	2.99	57.1	55.6	53.3
LSD (p=0.05)			4.9	3.9	4.6	0.39	0.26	0.21	4.0	5.1	4.5

*Original figures in parentheses were subjected to angular transformation $(\sqrt{x+1})$ before statistical analysis; RM, ready-mix

It may be concluded that sulfosulfuron 25 g/ha, sulfosulfuron + metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha or pinoxaden 50 g/ha could effectively be used to control grassy weeds particularly *P. minor* in sugarcane + wheat intercropping system. Clodinafop 60 g/ha, fenoxaprop 100 g/ha and carfentrazone showed phyto-toxicity to the sugarcane crop.

REFERENCES

Bhullar MS, Kamboj A, Singh GP. 2006. Weed management in spring planted sugarcane based intercropping systems. *Indian Journal of Agronomy* **51**(3): 183–185.

Fahad S, Nie L, Rahman A, Chen C, Wu C, Saud S and Huang J. 2013. Comparative efficacy of different herbicides for weed management and yield attributes in wheat. *American Journal of Plant Sciences* **4**: 1241–1245.

IISR. 2017. Technologies developed by Indian Institute of Sugarcane Research, Lucknow. *http://www.iisr.nic.in/research/technologies.htm,* assessed on 6 March, 2017.

Kamboj BR, Malik RK, Garg R, Yadav A, Singh S, Goyal NK, Lathwal OP, Malik YP and Mehla OP. 2008. *Bed planting - A novel technique to encourage multiple land use. Technical Bulletin (29).* Directorate of Extension Education, CCS Haryana Agricultural University, *Hisar, India*, 24 p.

Kumar R, Singh J and Uppal SK. 2017. Management of weeds in sugarcane-wheat intercropping system in sub-tropical India. *Indian Journal Weed Science* **19**(2): 139–146.

Pandey MB and Shukla SK. 2001. Response of sugarcane (*Sacharum* spp. Hybrid complex) to planting seasons and nitrogen levels. *Indian Journal of Agricultural Sciences* **71**(4): 261–63.

Patil MP, Naik PL, Metha NJ, Patel HS and Naik BC. 1991. Derbicidal control of weeds in sugarcane. *Indian Sugar* **16**: 309–312.

Rana NS, Kumar S, Saini SK and Panwar GS. 2006. Production potential and profitability of autumn sugarcane-based intercropping systems as influenced by intercrops and row spacing. *Indian Journal of Agronomy* **51**(1): 31–33.

Singh G, Singh OP, Singh RS and Yadav RA. 1990. Response of sugarcane to planting seasons and fertility levels. *Indian Journal of Agronomy* **35**(3): 315–316.

Singh K, Bhullar MS and Singh RS. 2007. Productivity and profitability of autumn sugarcane based intercropping systems in south-western Punjab. *Journal of Research Punjab Agricultural University* **44**: 18–20.

Singh R, Singh B and Chauhan KNK. 1999. Productivity and economics of Indian mustard as influenced by varieties and different weed control treatments. *Indian Journal of Weed Science* **31**(3/4): 138–141.

Srivastava TK, Chauhan RS and Lal M. 2005. Weed dynamics and their management under different preceding crops and tillage systems. *Indian Journal of Agricultural Sciences* **75**: 256–260.