Indian Journal of Agricultural Sciences **85** (5): 655–60, May 2015/Article
https://doi.org/10.56093/ijas.v85i5.48499

Bio-efficacy and selectivity of different herbicides against weed flora in wheat (*Triticum aestivum*)

SURESH PAL[1], RAJVIR SHARMA[2], H B SHARMA[3], RAGHAVENDRA SINGH[4] and SUBHASH BABU[5]

R B S College, Bichpuri, Agra, Uttar Pardesh 283 105

Received: 4 February 2014; Accepted: 3 October 2014

ABSTRACT

Field experiment was carried out during two consecutive *rabi* seasons of 2008-09 and 2009-10 at Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi, to evaluate the bio-efficacy and selectivity of different herbicides against weed flora in wheat (*Triticum aestivum* L.). Data reveals that readymix applications of mesosulfuron+iodosulfuron (24.0 + 4.8 g/ha) caused the highest reduction in the total weed density and weed dry matter accumulation during both the years at all stages of crop growth which however was statistically at par with mesosulfuron+iodosulfuron (18.0+3.6 g/ha), sulfosulfuron+ metsulfuron (20.0 + 4.0 g/ha), and clodinafop+metsulfuron (60.0 + 4.0 g/ha). With regards to yield attributes and grain yield, application of sulfosulfuron and metsulfuron (20.0+4.0 g/ha) were recorded the maximum values of effective tillers/plant (11.81 and 10.09), length of ear head (10.47 and 9.95 cm), spikelet ear/head (18.29 and 17.89) and number of grains ear/head (53.43 and 53.22) and grain yield (5.57 and 5.17 tonnes/ha) which was closely followed by weed free, mesosulfuron+iodosulfuron (24.0+4.8 g/ha) and (18.0+3.6 g/ha), tank mix clodinafop+metsulfuron (60.0+4.0 g/ha) during both the years. With respect to economics, highest B:C ratio (1.72 and 1.65) were recorded with the application of sulfosulfuron and metsulfuron (20.0+4.0 g/ha) during both the years.

Key words: Efficacy, Evaluation, Weed density, Weed dry matter, Yield, Yield attributes

In India, wheat (*Triticum aestivum* L.) is the second most important food crop being next to rice with the acreage and production of 27.75 million ha and 80.68 mt, respectively (Singh *et al.* 2013). India's shares in world wheat acreage and production are 12.40% and 11.63%, respectively (Varshney *et al.* 2012). In India, Punjab has the highest productivity of 43 q/ha, which is far ahead of the national productivity but far below its yield potential, i.e. 70 q/ha. The productivity of the wheat depends upon on several factors like crop establishment techniques, irrigation, weed management and fertilizers management and other cultural practices. Among these factors the hidden war with crop starts by weeds and it caused up to 90 per cent failure of the crop. The presence of weeds within the crop may adversely affect production in a number of ways. Weeds compete with crop species for water, nutrients and light and ultimately reduce crop yield. The traditional method of weed control has been practiced since, long like manual weeding, which is time consuming, labour intensive and finally become uneconomical. With the adoption of high yielding varieties of wheat under intensive mechanized agricultural, weed infestation has become a serious problem and major production constraint of wheat crop in the country. In intensive, agriculture particularly in situation of the morphological similarity of weeds with crop plants (crop mimicry), chemical control of weeds has become obligatory. Herbicides tried in early eighties having narrow window for controlling the weed flora which may caused a shift in weed flora in favour of some broad leaved weeds. In wheat, sole dependence on post-applied herbicides for weed control has resulted in the evolution of multiple herbicide resistance (Kumar *et al.* 2013). Hence, the herbicides used patterns need to be rationalized in such a way that problem associated with such type of use pattern can be avoided in the future. Under such conditions we need to evaluate suitable alternative herbicides for the control of complex weed flora in wheat amongst new herbicide groups introduced recently against grasses and broad leaved weeds. Some of the new herbicides which belong to sulfonylurea group of herbicides are known to control grassy weeds effectively. While some other herbicides of the same group are reported to provide effective control of broad-leaved weeds including hardy weeds. To avoid the use of herbicides separately for the

[1]Chief Technical Officer (e mail: sureshpal64@gmail.com), ASRB, KAB-1, Pusa, New Delhi 110 012; [2]Principal Scientist (e mail: drrajvir@iari.res.in), Division of Agronomy, IARI, Pusa, New Delhi 110 012; [3]Former Dean & Head, R B S College, Bichpuri, Agra 283 105; [4&5]Senior Scientist (e mail: subhiari@gmail.com) and Scientist-Agronomy (e mail: raghavenupc@gmail.com) ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok, Sikkim 737 102

control of broad-leaved and grassy weeds, a selective herbicides alone or mix application for broad spectrums of weed control is needed. Keeping in view the losses due to weed infestation, high cast of manual loabour and hazardous effect of narrow spectrum herbicides, the present investigation was undertaken to test the efficacy and selectivity of different herbicides for weed control in wheat.

MATERIALS AND METHODS

A field experiment was carried out during two consecutive *rabi* seasons of 2008-09 and 2009-10 at Research Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi, which is situated at a latitude of 28°40' N, longitude of 77°12' E and altitude of 228.6 meters above the mean sea level (Arabian Sea). The soils of experimental field was sandy-loam in texture having 155.40 kg/ha alkaline permanganate oxidizable N, 9.73 kg/ha available P, 162.11 kg/ha 1 *N* ammonium acetate exchangeable K and 0.38% organic carbon. The pH of soil was 7.25 (1:2.5 soil and water ratio). Field capacity, permanent wilting point and bulk density recorded were 17.81% (w/w), 4.19% (w/w) and 1.50 Mg/m, respectively in 0-15 cm soil depth. The experiment was laid out in randomized block with twelve weed control treatments, viz T_1 (Mesosulfuron+Iodosulfuron @ 12+2.4 g/ha), T_2 (Mesosulfuron+Iodosulfuron @ 18+3.6 g/ha), T_3 (Mesosulfuron+Iodosulfuron @ 24+4.8 g/ha), T_4 (Sulfosulfuron@ 25 g/ha), T_5 (Metsulfuron methyl @ 6 g/ha),T_6 (Clodinafop @ 60 g/ha), T_7 (Sulfosulfuron + Metsulfuron methyl @ 20+4.0 g/ha), T_8 (Clodinafop + Metsulfuron methyl @ 60+4.0 g/ha), T_9 (Isoproturon @ 1000 g/ha), T_{10} (2,4-D Na salt @ 750 g/ha), T_{11} (Weedy check) and T_{12} (Weed free). All the treatments replicated thrice during both the years of experimentation. A pre-sowing irrigation was given for land preparation. After the drainage of excess water, field was disc harrowed twice under the workable condition followed by planking with a wooden plank for leveled properly. After laying out the experiment, recommended doses of nitrogen and phosphorus were given in the form of urea and single super phosphate. Half of the recommended dose of N (120 kg/ha) and full dose of P (60 kg/P_2 O_5/ha) and K (60 kg/K_2O ha) were applied as basal dose and remaining half of nitrogen was top dressed into two equal splits. The seed of wheat variety PBW 343 was sown in rows spaced 22.5 cm with tractor drawn seed drill calibrated for recommended seed rate of 100 kg/ha. All the herbicides were applied at 30 DAS with the help of knapsack sprayer fitted with a flat fan nozzle with a spray volume of 500 l/ha. The weed free plot was maintained by repeated manual weeding. The wheat crop was grown as per recommended practices and was harvested on 5 and 7 of April in both the year of experimentation, respectively. Weed population count and weed samples for dry matter production was taken to assess the effect of various treatments on weeds growth. For counting of weed population, an area of 0.25 m^2 was selected randomly by throwing a metallic quadrate of size 0.25 m × 0.25 m at two places at 40, 80, and 120 DAS and at harvest and expressed on square meter basis (No./m^2). For dry matter accumulation the collected weed sample from 0.5 m ^{2} area were first sun dried and then in an electric oven at 70°C till the constant weight was achieved. Observation on yield attributes and yield of crop were recorded as per the standared procedures. Cost of cultivation was calculated based on the prevailing market prices of the inputs during the respective crop seasons. Gross returns were calculated based on the grain and straw yield and their prevailing market prices during the respective crop seasons. Net returns were calculated by subtracting cost of cultivation from gross returns. Net B:C ratio was calculated by dividing the net returns with cost of cultivation. The original data on weed density and their dry weight at all stages were subjected to square root transformation $\sqrt{X+0.5}$ before statistical analysis to analyze the significant effect of different weed control treatments on weed growth. The original values are given in parentheses. All the data obtained from the experiment during two consecutive years were statistically analyzed using the *F*-test procedure given by Gomez and Gomez (1984). Least significant difference (LSD) values at *P*=0.05 were used for determine the significance of differences between means.

RESULTS AND DISCUSSION

Effect of herbicidal treatments on weeds

Weed density: In general weed density was higher in first year as compared to the second year of experimentation. This might be due to higher and uniform distribution of rainfall, which could have favoured of weed growth. Total weed population was significantly influenced due to different weed control treatments at all stages of crop growth during both the years (Table 1). This may be attributed to the inhibition of the germination of weeds owing to paralysis of vital metabolic process, viz. cell division, protein synthesis etc. and subsequently drying of susceptible weeds species. In general, there was decreasing trend in the total weed population in most of the herbicidal treatments except clodinafop at 60 g/ha and isoproturon at 1000 g/ha with the advancement of crop growth. Among herbicidal treatments, readymix applications of mesosulfuron+iodosulfuron (24.0 + 4.8 g/ha) caused the highest reduction in the total weed density during both the years at all stages of crop growth which however was statistically at par with mesosulfuron+iodosulfuron (18.0+3.6 g/ha), sulfosulfuron+ metsulfuron (20.0 + 4.0 g/ha) and clodinafop+metsulfuron (60.0 + 4.0 g/ha). The reduction in the population of all weeds was not affected equally by all herbicidal treatments. This was due to the fact that clodinafop, isoproturon and sulfosulfuron could not control the dominant population of broad leaved weeds in both the years as they are effective against grasses. These findings were supported with the work done by Singh *et al.* (2008).

Dry matter accumulation by weed: Variation in the weed infestation density resulted in significant variation in

Table 1 Weed density as influenced by different weed control measures

Treatment	2008-2009				2009-2010			
	Days after sowing				Days after sowing			
	40	80	120	At harvest	40	80	120	At harvest
Meso+Iodo @ 12+2.4 g/ha	10.19 (103.20)*	6.20 (37.94)	5.87 (33.98)	5.72 (32.22)	11.87 (140.39)	7.95 (62.74)	7.73 (59.25)	7.17 (50.91)
Meso+Iodo @ 18+3.6 g/ha	7.39 (54.11)	3.73 (13.38)	3.20 (9.74)	2.85 (7.62)	9.02 (80.84)	4.86 (23.08)	4.20 (17.14)	3.99 (15.42)
Meso+Iodo @ 24+4.8 g/ha	7.03 (48.92)	3.54 (12.03)	2.98 (8.38)	2.63 (6.41)	8.75 (76.06)	4.70 (21.59)	4.07 (16.06)	3.95 (15.10)
Sulfosulfuron @ 25 g/ha	10.98 (120.06)	12.73 (161.44)	9.89 (97.23)	9.66 (92.81)	12.72 (161.30)	13.13 (172.00)	12.44 (154.24)	12.17 (147.67)
Metsulfuron @ 6 g/ha	9.21 (84.32)	5.82 (33.37)	5.51 (29.86)	4.93 (23.80)	10.86 (117.44)	6.77 (45.27)	5.63 (31.17)	5.53 (30.08)
Clodinafop @ 60 g/ha	12.92 (166.43)	16.12 (260.35)	14.51 (210.25)	13.32 (176.92)	14.72 (216.27)	15.38 (236.04)	14.30 (204.05)	13.99 (195.22)
Sulf + Met @ 20+4 g/ha	7.68 (58.48)	4.25 (17.60)	3.91 (14.79)	3.66 (12.90)	9.96 (98.76)	5.04 (24.90)	4.99 (24.40)	4.81 (22.64)
Clodi +Met @ 60+4 g/ha	7.86 (61.28)	4.20 (17.17)	3.86 (14.40)	3.58 (12.32)	9.96 (98.64)	5.51 (29.86)	4.85 (23.02)	4.81 (22.61)
Isoproturon @ 1000 g/ha	13.32 (176.97)	16.34 (266.50)	15.25 (231.97)	12.94 (166.94)	15.08 (226.90)	15.93 (253.26)	14.84 (219.66)	14.62 (213.24)
2,4-D @ 750 g/ha	10.09 (101.31)	6.49 (41.62)	5.76 (32.68)	5.62 (31.08)	10.53 (110.38)	7.37 (53.82)	6.73 (44.79)	6.38 (40.20)
Weedy Check	14.77 (217.65)	17.21 (295.68)	16.30 (265.15)	14.82 (219.13)	16.98 (287.82)	18.17 (329.65)	16.89 (284.70)	16.78 (281.07)
Weed Free	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)
SEm±	0.29	0.26	0.31	0.28	0.42	0.32	0.33	0.31
LSD (P=0.05)	0.85	0.77	0.91	0.83	1.23	0.95	0.98	0.91

*Figure in the parentheses are in original value. Data were transformed through $\sqrt{X+0.5}$. Meso: Mesosulfuron, Iodo: Iodosulfuron, Sulfo: Sulfosulfuron , Clodi: Clodinafop, Met: Metsulfuron

the total dry matter production of weeds across the treatments over the years (Table 2). The magnitude of total weed dry matter accumulation was relatively higher in the second year of experimentation at all the stages of crop growth. In general, total weed dry matter accumulation followed the increasing trends with the advancement of crop growth stage across all the treatment except readymix application of mesosulfuron+iodosulfuron (18.0+3.6 g/ha), mesosulfuron+iodosulfuron (24.0+4.8 g/ha), tank mix application of metsulfuron at 4 g/ha with sulfosulfuron at 20 g/ha and clodinafop at 60 g/ha, metsulfuron alone at 6 g/ha and 2,4-D at 750 g/ha. Weedy check recorded significantly higher total dry weight of weeds at all the stages in both the years than rest of the treatments. Amongst herbicidal treatments ready mix application of mesosulfuron+iodosulfuron (24.0+4.8 g/ha) recorded the lowest total weed dry weight which was found statistically at par with mesosulfuron+iodosulfuron (18.0+3.6 g/ha), sulfosulfuron + metsulfuron (20.0+4.0 g/ha) and clodinafop+metsulfuron (60.0+4.0 g/ha) at all stages of crop growth during both the years. This might be due to the fact that combined application of two herbicides known for controlling grassy and non-grassy weeds separately, provided effective control of all the weeds to achieve high level of weed control. These results are corroborated with the findings of Singh *et al.* (2003) and Singh *et al.* (2008).

Effect of herbicidal treatments on crop performances

Yield attributes: All the yield attributing characteristics, viz. effective tillers/plant, length of ear head (cm), spikeles/ear head and number of grains/ear head were influenced significantly due to different weed control treatments. However, length of ear head (cm) and grains/ear head are the dominant genetic trait of plant described by breeder, but being the resultant of crop growth, they were significantly higher in weed free plots due to zero weed competition. Significant improvement in all attributes was obtained with the application of all herbicides probably because of lower weed population and dry weight. Relatively higher increase in yield attributes were recorded in tank mix application of sulfosulfuron and metsulfuron (20.0+4.0 g/ha) which was closely followed by weed

Table 2 Total dry weight as influenced by different weed control measures

Treatment	2008-2009				2009-2010			
	Days after sowing				Days after sowing			
	40	80	120	At harvest	40	80	120	At harvest
Meso+Iodo @ 12+2.4 g/ha	5.57 (30.52)*	6.08 (36.50)	6.07 (36.34)	6.42 (40.68)	5.99 (35.42)	6.37 (40.08)	6.91 (47.25)	6.71 (44.52)
Meso+Iodo @ 18+3.6 g/ha	3.61 (12.53)	3.33 (10.57)	2.92 (8.01)	2.40 (5.25)	4.71 (21.68)	4.57 (20.38)	4.32 (18.19)	4.07 (16.04)
Meso+Iodo @ 24+4.8 g/ha	3.45 (11.40)	2.93 (8.08)	2.61 (6.31)	2.33 (4.93)	4.49 (19.66)	4.30 (17.99)	4.31 (18.10)	4.06 (16.01)
Sulfosulfuron @ 25 g/ha	4.96 (24.10)	6.61 (43.19)	7.80 (60.29)	7.50 (55.71)	6.44 (40.97)	7.4 (54.30)	8.16 (66.09)	7.91 (62.12)
Metsulfuron @ 6 g/ha	5.54 (30.19)	4.11 (16.39)	3.54 (12.03)	3.22 (9.86)	6.52 (42.01)	5.98 (35.26)	5.75 (32.56)	5.52 (29.97)
Clodinafop @ 60 g/ha	5.00 (24.50)	7.52 (56.10)	8.37 (69.51)	8.15 (65.97)	6.47 (41.36)	7.73 (59.30)	8.59 (73.29)	8.26 (67.68)
Sulf + Met @ 20+4 g/ha	3.63 (12.70)	3.31 (10.46)	2.95 (8.18)	2.39 (5.23)	4.66 (21.21)	4.63 (20.93)	4.32 (18.16)	4.27 (17.76)
Clodi +Met @ 60+4 g/ha	3.58 (12.32)	3.39 (10.99)	3.05 (8.80)	2.46 (5.57)	4.81 (22.66)	4.78 (22.35)	4.33 (18.25)	4.20 (17.14)
Isoproturon @ 1000 g/ha	6.00 (35.5)	8.05 (64.30)	9.17 (83.59)	8.94 (79.42)	7.47 (55.35)	8.47 (71.24)	9.22 (84.45)	8.95 (79.66)
2,4-D @ 750 g/ha	5.83 (33.48)	4.46 (19.39)	3.73 (13.41)	3.26 (10.12)	6.82 (46.01)	6.10 (36.71)	5.94 (34.78)	5.78 (32.90)
Weedy Check	6.50 (41.75)	8.90 (78.71)	11.99 (143.19)	12.08 (145.35)	7.82 (60.65)	8.99 (80.27)	12.15 (147.12)	12.19 (148.10)
Weed Free	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)
SEm±	0.15	0.21	0.22	0.24	0.17	0.14	0.23	0.26
LSD (P=0.05)	0.45	0.61	0.66	0.70	0.49	0.42	0.69	0.77

* Figure in the parentheses are original value. Data were transformed through $\sqrt{X+0.5}$. Meso: Mesosulfuron, Iodo: Iodosulfuron, Sulfo: Sulfosulfuron, Clodi: Clodinafop, Met: Metsulfuron

free, mesosulfuron+iodosulfuron (24.0+4.8 g/ha) and (18.0+3.6 g/ha), tank mix clodinafop+metsulfuron (60.0+4.0 g/ha) in both the years. This could be attributed to their significant effect on both grassy and broad leaved weeds in comparison to other herbicides. Which may provide the congenial environment for crop growth. The results are in accordance with the finding of Singh *et al.* (2003). The lowest values of all the yield attributing characters were recorded under, season long weed condition. This was due to the fact that wheat plants in weedy check plots were under competitive stress for all resources and thereby produced, least effective tillers (8.11 and 7.45), the smallest ear head (7.39 and 7.27cm), fewer spikelets/ear head (16.48 and 15.38) and fewer grains/ear head (43.66 and 44.00). Similar observations were also recorded by Dixit and Bhan (1997).

Yields: Grain yield is a product of yield attributing characters of any crop. Therefore maximum expressions of yield attributes, viz. effective tillers, ear head, length of ear head, grains numbers and spikelets numbers/ear head due to reduced crop-weed competition in weed free plots resulted in the highest increase in grains yield by 51.97% and 53.45% in 2008-09 and 2009-10, respectively as compared to season long weed infestation (Table 4). In general grain yield was comparatively lower in 2009-10 than 2008-09. This was due to late sowing of wheat wherein the period required for ear and grain development was not sufficient and the increased temperature during the March to April, coincided with the grain development leading the force maturity of the crop. Similar finding was also reported by Singh *et al.* (1997). Besides the above facts relatively higher and frequent rainfall received during crop growth period in second year might have also encouraged the second flush of weeds, resulting in higher weed population and lower grain yield in comparison to first year of the experimentation. All the herbicidal treatment significantly increases the grain and straw yield over weedy check during both the years. Among the herbicides, tank mix application of sulfosulfuron + metsulfuron (20+4 g/ha), clodinafop + metsulfuron (60.0+4.0 g/ha), ready mix application of mesosulfuron+iodosulfuron (24.0+4.8 and 18.0+3.6 g/ha) and metsulfuron 6 g/ha were comparable to weed free plot in terms of grain and straw yield in both the years. However, maximum grain yield (5.57 and 5.17 tonnes/ha), straw yield (8.85 and 8.35 tonnes/ha) and biological yield (14.42 and 13.52

Table 3 Effect of different weed control treatment on yield attributes of wheat crop

Treatment	Effective tillers/plant		Ear length (cm)		No. of spikelets		Grains/ear head	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Meso+Iodo @ 12+2.4 g/ha	9.45	8.47	8.50	8.30	17.13	16.83	46.89	45.11
Meso+Iodo @ 18+3.6 g/ha	10.99	10.00	10.25	9.87	18.00	17.51	52.29	52.15
Meso+Iodo @ 24+4.8 g/ha	11.00	10.05	10.14	9.90	18.11	17.56	52.90	52.56
Sulfosulfuron @ 25 g/ha	10.00	9.11	9.57	9.27	17.00	16.80	48.45	46.00
Metsulfuron @ 6 g/ha	10.35	9.17	9.74	9.40	17.59	16.86	50.00	48.88
Clodinafop @ 60 g/ha	9.55	9.00	9.49	9.19	16.82	16.20	47.00	47.45
Sulf + Met @ 20+4 g/ha	11.81	10.09	10.47	9.95	18.29	17.89	53.43	53.22
Clodi +Met @ 60+4 g/ha	11.00	10.06	10.38	9.64	18.26	17.87	52.44	52.24
Isoproturon @ 1000 g/ha	9.11	9.10	9.35	9.15	16.80	16.20	47.11	46.00
2,4-D @ 750 g/ha	10.30	9.14	9.54	9.20	17.55	16.85	49.86	48.90
Weedy check	8.11	7.45	7.39	7.27	16.48	15.38	43.66	44.00
Weed Free	12.00	10.85	11.03	10.55	19.33	18.53	53.89	53.61
SEm±	0.37	0.30	0.36	0.31	0.47	0.48	1.76	1.61
LSD (P=0.05)	1.10	0.89	1.05	0.93	1.38	1.41	5.19	4.76

Meso: Mesosulfuron, Iodo:Iodosulfuron, Sulfo: Sulfosulfuron , Clodi: Clodinafop, Met: Metsulfuron

Table 4 Effect of different weed control treatment on grain, straw, biological yields and gross returns, net returns and B:C ratio

Treatment	Grain yield (tonnes/ha)		Straw yield (tonnes/ha)		Biological yield (tonnes/ha)		Gross returns (×10³₹/ha)		Net returns (×10³₹/ha)		B:C ratio	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Meso+Iodo @ 12+2.4 g/ha	4.28	3.97	7.02	6.45	11.30	10.42	46.86	48.38	25.70	24.36	1.21	1.01
Meso+Iodo @ 18+3.6 g/ha	5.23	5.03	8.25	8.14	13.48	13.17	56.90	61.25	35.15	36.72	1.62	1.50
Meso+Iodo @ 24+4.8 g/ha	5.35	5.12	8.33	8.08	13.68	13.20	59.93	62.04	37.50	36.82	1.67	1.46
Sulfosulfuron @ 25 g/ha	4.83	4.46	7.85	7.29	12.68	11.75	52.81	54.42	31.56	30.38	1.48	1.26
Metsulfuron @ 6 g/ha	5.10	4.87	8.25	8.02	13.35	12.89	52.41	59.49	32.36	36.64	1.61	1.60
Clodinafop @ 60 g/ha	4.73	4.25	7.40	6.68	12.13	10.93	51.36	51.46	30.11	27.41	1.42	1.14
Sulf + Met @ 20+4 g/ha	5.57	5.17	8.85	8.35	14.42	13.52	57.09	62.93	36.12	39.16	1.72	1.65
Clodi +Met @ 60+4 g/ha	5.44	5.10	8.35	8.14	13.79	13.24	57.72	61.94	36.44	38.05	1.71	1.59
Isoproturon @ 1000 g/ha	4.60	4.20	7.60	6.85	12.20	11.05	50.46	51.23	30.17	28.14	1.49	1.22
2,4-D @ 750 g/ha	4.93	4.61	8.00	7.62	12.93	12.23	53.90	56.38	33.81	24.49	1.68	0.77
Weedy check	2.90	2.79	4.95	4.88	7.85	7.67	31.25	34.52	12.19	16.46	0.64	0.91
Weed free	5.58	5.22	8.87	8.63	14.45	13.85	59.05	63.84	36.90	36.04	1.67	1.30
SEm±	0.18	0.13	0.27	0.24	0.4.5	0.44						
LSD (P=0.05)	0.54	0.39	0.82	0.72	1.3.5	1.30						

Meso: Mesosulfuron, Iodo:Iodosulfuron, Sulfo: Sulfosulfuron, Clodi: Clodinafop, Met: Metsulfuron

tonnes/ha) were recorded with the tank mix application of sulfosulfuron + metsulfuron (20+4 g/ha) during both the years, respectively. The better performance of these treatments could be attributed to better expressions of their yield due to reduction in crop-weed competition. This could be due to their selectivity to crop and significant reduction in on both grassy and non-grassy weeds. Crop yield loss was negatively correlated to weed biomass averaged over the cropping season (Colbach *et al.* 2014). Similar findings were also recorded by Balyan and Malik (2000) and (Singh *et al.* 2003). Dry matter accumulation in straw and biological yield constituting both grain and straw followed almost similar trend to those obtained in grain yield under different weed control treatments in both the years and therefore followed the same result and the same justification may hold true.

Economics

Getting maximum profitability lies not only in reducing use of input per unit area but also in lowering costs per unit crop production through higher yields. Therefore, economic analysis is required for making recommendation for farmers from agronomic experiments. The net return and B:C ratio varied with different weed control treatment. The highest net return of ₹ 37.49 × 10^3/ha and ₹ 38.05 × 10^3/ha were obtained with the application of ready mix formulation of mesosulfuron + iodosulfuron (24.0+4.8 g/ha) and with tank-mix application of clodinafop + metsulfuron (60+4 g/ha) in 2008-09 and 2009-10, respectively. With regards to B:C ratio, the higher value of B:C ratio 1.72 and 1.65 was obtained with the tank-mix application of sulfosulfuron+metsulfuron (20+4 g/ha) during both years, which indicate to be the most remunerative weed control treatment (Table 4). The weed management with sulfosulfuron+metsulfuron methyl (20.0+4.0 g/ha) appeared to be economically viable when even labour shortage is arises.

An overall analysis of data showed that tank mix application of sulfosulfuron+metsulfuron (20+4 g/ha), were found an economical viable option for controlling the weed flora in wheat during both the years. Therefore, application of sulfosulfuron+metsulfuron (20+4 g/ha) may be recommended for effective weed control in wheat for Delhi condition.

REFERENCES

Balyan R S and Malik R K. 2000. New herbicides for jangali palak (*Rumex retroflexus* L.). *Indian Journal of Weed Sciences* **32**(1&2): 86–8.

Colbach N, Collard A, Guyot S H M, Mézière D and Jolain N M. 2014. Assessing innovative sowing patterns for integrated weed management with a 3D crop:weed competition model. *European Journal of Agronomy* **53:** 74–89.

Dixit A and Bhan V M. 1997. Weed control efficacy of isoproturon applied at different concentration and its combination with 2, 4-D in wheat. *Indian Journal of Weed Sciences* **29**(1&2): 11–4

Gomez K A and Gomaz A. 1984. *Statistical Procedures for Agricultural Research.* John Wiley & Sons, Singapore.

Kumar V, Singh S, Chhokar R S, Malik R K, Brainard D C and Ladha J K. 2013. Weed management strategies to reduce herbicide use in zero-till rice-wheat cropping systems of the Indo-Gangetic Plains. *Weed Technology* **27**(1): 241–54.

Singh G, Singh V P and Singh M. 2003. Studies on the effect of mesosulfuron and iodosulfuron on weeds in wheat, their compatibility with other chemicals and residual effects on succeeding crops. *Indian Journal of Weed Sciences* **35**(3&4): 173–8.

Singh H, Jha G, Rawat A, Babu Subhash and Jha A K. 2013. Low seed rate at surface sowing enhance resilience of physiological parameters and economics of wheat (*Triticum aestivum* L.). *Indian Journal of Agricultural Sciences* **83** (8): 881–4.

Singh S, Malik R K, Singh H and Narwal S. 2003. Evaluation of ready-mix of mesosulfuron+iodosulfuron for weed control in wheat. *Indian Journal of Weed Sciences* **35**(3&4): 190–3.

Singh S, Punia S S, Balyan R S and Malik R K. 2008. Efficacy of tribenuron methyl applied alone and tank mix against broadleaf weeds of wheat (*Triticum aestivum* L.). *Indian Journal of Weed Sciences* **40**(3&4): 109–20.

Singh S, Singh A N and Bhan V M. 1997. Studies on the chemical weed control in wheat. *Indian Journal of Weed Sciences* **29**(3&4): 100–2.

Varshney S, Hayat S, Alyemeni M N and Ahmad A. 2012. Effects of herbicide applications in wheat fields. Is phytohormones application a remedy? *Plant Signaling and Behavior* **7**(5): 570–5.