Indian Journal of Agronomy **61** (1): 59–63 (March 2016)

Research Paper

Influence of different herbicides on weed control, nutrient removal and yield of wheat (*Triticum aestivum*)

SURESH PAL[1], RAJVIR SHARMA[2], H.B. SHARMA[3] AND RAGHAVENDRA SINGH[4]

Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh 283 105

Received : May 2015; Revised accepted : February 2016

ABSTRACT

A field experiment was carried out during 2 winter (*rabi*) seasons of 2008–09 and 2009–10 at New Delhi, to evaluate the efficacy of different herbicides on weed population, productivity and nutrients acquisition of wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.]. Among the herbicidal treatments, ready-mix applications of mesosulfuron + iodosulfuron (24 + 4.8 g/ha) recorded the lowest weed density and NPK removal by weeds. However, this treatment remained statistically at par with mesosulfuron + iodosulfuron (18 + 3.6 g/ha), sulfosulfuron + metsulfuron (20 + 4 g/ha) and clodinafop + metsulfuron (60 + 4 g/ha). Application of sulfosulfuron and metsulfuron (20 + 4 g/ha) recorded the maximum values of plant height (89.81 cm at harvesting), number of tillers/m (93.39 at harvest), dry-matter accumulation, grain yield (5.23 t/ha) and nutrients uptake (142.4 kg N, 18.90 kg P and 117.23 kg K/ha), which was closely followed by weed-free, mesosulfuron + iodosulfuron (24 + 4.8 g/ha), (18 + 3.6 g/ha) and tank-mix clodinafop + metsulfuron (60 + 4 g/ha).

Key words : Herbicide efficacy, Herbicide mixture, Nutrients removal, Weed-management

Wheat is the most important staple food crop for the whole world. Its production is directly affected by several factors and one of the most limiting factor is infestation of weeds. Weed reduces the yield of wheat up to 50% based on the infestation (Azad, 2003). It is due to some dominated weed flora appearing at early stage and the luxuriant growth of weeds because of frequent irrigation and dominancy of monotony cropping system. For realizing full genetic yield potential of the crop, the proper weed control is one of the indispensible aspect. Weeds not only reduce the yield but also make the harvesting operation difficult. Therefore, for sustaining foodgrain production to feed burgeoning population and ensuring food security, effective weed management is very essential. Manual removal of weeds in wheat crop is laborious, time-consuming and uneconomical due to higher rate of labour wages. Therefore, chemical control of weeds is the preferred option. Farmers of the region generally used herbicides for weed control in wheat which has monotonous mode of action. This type of herbicide patterns has caused a shift in weed flora in favour of some broad-leaf weeds. It has also led to the development of resistance against widely used herbicide in weed species like *Phalaris minor* against isoproturon (Malik and Malik, 1994). 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.

Use of herbicides in rotation or as tank-mix application may help not only increase the spectrum of weed control but also prevent or delay the development of weed resistance. 2,4-D is still providing excellent control of broad-leaf weeds though is known to cause developmental deformities in certain wheat cultivars which subsequently results in reduction of the yield (Balyan and Malik, 2000). Use of non-conventional herbicides may not be expectable due to their injury/toxicity to wheat crop (Balyan, 1999). 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-leaf weeds. Some of the new herbicides which belong to sulfonylurea group are known

Based on a part of the Ph.D. thesis of first author submitted to Dr Bhim Rao Ambedkar University, Agra, Uttar Pradesh (unpublished)

[4]**Corresponding authors Email:** raghavenupc@gmail.com; sureshpal64@gmail.com

[1]Chief Technical Officer, ASRB, KAB-1, Pusa, New Delhi 110 012; [3]Former Head and Dean, Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh 283 105; [2]Head, ICAR-RCER Research Centre for Makhana, Darbhanga, Bihar 800 014; [4]Senior Scientist (Agronomy), ICAR-Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok 737 135

to control grassy weeds effectively. While some other herbicides of the same group are reported to provide effective control of broad-leaf weeds including hardy weeds. To avoid the use of herbicides separately for the control of broad-leaf and grassy weeds, a selective herbicides alone or mix application for broad spectrum of weed control is needed. Hence, a comprehensive study was undertaken to keep the weeds below threshold level and assess the effect of different herbicide mixtures on crop growth, yield performance and nutrients acquisition of wheat.

MATERIALS AND METHODS

A field experiment was carried out during winter (*rabi*) seasons of 2008–09 and 2009–10 at Research Farm, Division of Agronomy, Indian Agricultural Research Institute, New Delhi, (28°40' N, 77°12' E and 228.6 m mean sea-level). The soils was sandy loam, 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 *p*H of soil was 7.25 (1: 2.5 soil: 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^3, respectively, in 0–15 cm soil depth. The experiment was laid out in randomized block with 12 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 @ 1,000 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. Field was prepared using disc harrowing twice at workable conditions followed by planking with wooden plank for proper leveling. After laying out the experiment, recommended doses of nitrogen and phosphorus were given in the form of urea and single superphosphate. Half of the recommended dose of N (120 kg/ha) and full dose of P (60 kg P_2O_5/ha) and K (60 kg K_2O/ha) were applied basal and remaining nitrogen was top-dressed into 2 equal splits. The seed of wheat variety 'PBW 343' was sown in rows, spaced 22.5 cm with tractor-drawn seed drill using seed rate of 100 kg/ha 16 and 25 November during the first and second year of experimentation, respectively. 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 litres/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 April during first and second year respectively. For counting of weed population, an area of 0.25 m^2 was selected randomly by throwing a metallic quadrate of size 0.50 m × 0.50 m at 2 places at 40, 80, and 120 days after sowing (DAS) and at harvesting and expressed on square meter basis (No./m^2). Observation on crop growth, yield attributes and yield were recorded. For nutrients removal study the weed samples collected were ground into fine powder and passed through a 40 mm mesh sieve and used for analysis of nitrogen, phosphorus and potassium concentration in plants and the uptake of these nutrients. Nitrogen was estimated by Kjeldahl's method, phosphorus by Vanado-molybdophosphoric yellow colour method and potassium content was determined using flame photometry method. The uptake of nutrients was computed by multiplying dry- matter accumulation in hectare by their respective nutrient contents. The original data on weed density at all stages were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis to analyze the significant effect of weed-control treatments on weed growth. All the data obtained 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

Weeds

All the weed-control treatments recorded significantly lower weed density than weedy check (Table 1). Among the herbicidal treatments, ready mix application of mesosulfuron + iodosulfuron (24 + 4.8 g/ha) exerted the maximum herbicidal effect and caused the highest reduction in the total weed density at all stages of crop growth, which however, was statistically at par with mesosulfuron + iodosulfuron (18 + 3.6 g/ha). This attributed to the inhibition of the germination of weeds due to paralysis of vital metabolic process of germination, viz. cell-division, protein synthesis and secretion of hydrolytic enzymes, and subsequently drying of susceptible weeds species. This might be due to the fact that combined application of 2 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 confirm the findings of Singh *et al.* (2003) and Ziveh and Mahdavi, (2012). With reference to the nutrients removal by weeds, nutrients uptake by weeds was significantly influenced by all weed control treatments compared with the weedy check (Table 3). Among the herbicidal treatments, ready-mix application of mesosulfuron + iodosulfuron (24 + 4.8 g/ha) resulted in the lowest uptake of NPK (2.12, 0.56 and 1.40 kg/ha) by weeds; however, it remained statistically on a par with the application of mesosulfuron +

iodosulfuron (18 + 3.6 g/ha), sulfosulfuron + metsulfuron (20 + 4 g/ha) and clodinafop + metsulfuron (60 + 4 g/ha). The NPK uptake by weeds was significantly higher under treatment of metsulfuron @ 6 g/ha, 2, 4-D @ 750 g/ha and mesosulfuron + iodosulfuron (12 + 2.4 g/ha)-treated plots. This was due to the fact that weeds-control treatments controlled both the grassy and non-grassy weeds effectively and consequently resulting in lesser uptake of nutrients by weeds. However, the highest uptake of NPK by weeds was recorded in isoproturon (1,000 g/ha)-treated plots followed by clodinafop (60 g/ha) and sulfosulfuron (25 g/ha)-treated plots. These results support the findings of Kanojia and Nepalia (2006).

Crop

Variation in growth attributes, viz. plant height (cm), tillers (no./m) and dry-matter accumulation (g/m) of the wheat at both the stages of crop growth was observed with the weed-control treatments (Table 2). The tallest plant, maximum number of tillers/running m, and dry-matter accumulation were recorded in weed free plot, although this remained statistically at par with some of the herbicidal treatments, namely mesosulfuron + iodosulfuron (24 + 4.8 g/ha), sulfosulfuron + metsulfuron (20 + 4 g/ha),

Table 1. Effect of weed-control treatments on weed dynamics of wheat (mean data of 2 years)

Treatment	Weed density (Nos./m^2)					
	80 DAS		120 DAS		At harvesting	
Meso + iodo (12 + 2.4 g/ha)	7.1	(50.34)	6.8	(46.61)	9.3	(41.56)
Meso + iodo (18 + 3.6 g/ha)	4.3	(18.23)	3.8	(13.44)	3.4	(11.49)
Meso + iodo (24 + 4.8 g/ha)	4.1	(16.81)	3.5	(12.22)	3.3	(10.75)
Sulfosulfuron (25 g/ha)	12.9	(166.7)	11.1	(125.7)	10.9	(120.2)
Metsulfuron (6 g/ha)	6.3	(39.32)	5.6	(30.51)	5.2	(26.94)
Clodinafop (60 g/ha)	15.7	(248.1)	14.4	(207.1)	13.6	(186.0)
Sulf + met (20 + 4 g/ha)	4.6	(21.25)	4.5	(19.59)	4.2	(17.77)
Clodi + met(60 + 4 g/ha)	4.9	(23.51)	4.4	(18.710	4.2	(17.46)
Isopruturon (1,000 g/ha)	16.1	(259.8)	15.0	(225.8)	13.7	(190.0)
2,4-D (750 g/ha)	6.9	(47.72)	6.2	(38.73)	6.0	(35.64)
Weedy check	17.6	(312.6)	16.5	(274.9)	15.8	(250.0)
Weed-free	0.7	(0.00)	0.7	(0.00)	0.7	(0.00)
SEm±	0.29	–	0.32	–	0.29	–
CD (P=0.05)	0.86	–	0.91	–	0.87	–

Figures in the parentheses are original value. Data were transformed through $\sqrt{x + 0.05}$
Meso, Mesosulfuron; Iodo, iodosulfuron; Sulfo, sulfosulfuron; Clodi, clodinafop; Met, metsulfuron

Table 2. Effect of weed-control treatments on growth and yield of wheat (mean data of 2 years)

Treatment	Plant height (cm) at harvest	Tillers (Nos./m) at harvesting	DMA (g/m) at 80 DAS	Grain yield (t /ha)	Straw yield (t/ha)	Biological yield (t/ha)
Meso + iodo (12 + 2.4 g/ha)	80.9	83.8	96.4	4.12	6.73	10.86
Meso + iodo (18 + 3.6 g/ha)	88.5	91.9	108.1	5.13	8.19	13.32
Meso + iodo (24 + 4.8 g/ha)	89.8	93.4	108.9	5.23	8.20	13.45
Sulfosulfuron (25 g/ha)	83.1	88.2	102.0	4.64	7.57	12.21
Metsulfuron (6 g/ha)	84.8	87.7	106.6	4.98	8.13	13.12
Clodinafop (60 g/ha)	83.0	84.8	101.3	4.49	7.04	11.53
Sulf + met (20 + 4 g/ha)	88.8	91.7	112.8	5.37	8.60	13.97
Clodi + met (60 + 4 g/ha)	89.2	93.2	111.5	5.27	8.24	13.51
Isopruturon (1,000 g/ha)	79.8	84.6	100.0	4.40	7.22	11.62
2,4-D (750 g/ha)	81.9	86.7	105.4	4.77	7.81	12.58
Weedy check	73.7	73.2	77.3	2.84	4.91	7.76
Weed-free	90.1	93.9	114.0	5.40	8.75	14.15
SEm±	2.71	2.99	3.49	0.15	0.25	0.44
CD(P=0.05)	8.00	8.82	10.30	0.46	0.77	1.32

Meso, Mesosulfuron; Iodo, iodosulfuron; Sulfo, sulfosulfuron; Clodi, clodinafop; Met, Metsulfuron clodinafop + metsulfuron (60 + 4 g/ha), mesosulfuron + iodosulfuron (18 + 3.6 g/ha), metsulfuron @ 6 g/ha and sulfosulfuron @ 25 g/ha. This might be owing to better performance of both combined application of herbicide for controlling grassy and broad-leaf weeds and therefore resulted in less weed-crop competition as compared to their alone application. These results are in close conformity with those reported by Singh *et al*. (1997). Amongst the herbicidal treatments, ready-mix application of mesosulfuron + iodosulfuron (24 + 4.8 g/ha) revealed the highest values of all growth parameters which remained statistically at par with all the remaining herbicidal treatments except mesosulfuron + iodosulfuron (12 + 2.4 g/ha) and isoproturon at 1,000 g/ha. This might be because of better performance of ready-mix formulation against both grassy and non-grassy weeds. Comparative improvements in growth parameters of wheat with the application of new herbicides molecules as compared to the traditional herbicides were also reported by Paighan *et al.* (2013). Relatively poor performance of isoproturon was due to the fact that it could not control dominant population of broad-leaf weeds.

Two year's mean data showed that the weed-control treatments had significant influence on grain, straw and biological yields. However, the weed-control treatments had failed to affect the harvest index (Table 2). The highest grain, straw and biological yields was recorded in plots which were kept weed free for the entire crop season. However, weedy-free treatment resulted in statistically similar yields with sulfosulfuron + metsulfuron (20 + 4 g/ha), clodinafop + metsulfuron (60 + 4 g/ha), mesosulfuron + iodosulfuron (24 + 4.8 g/ha), mesosulfuron + iodosulfuron (18 + 3.6 g/ha) and metsulfuron 6 g/ha. As regard to herbicidal treatments, tank-mix application of sulfosulfuron + metsulfuron (20 + 4 g/ha) provided the highest grain, straw and biological yields, which however remained statistically at par with clodinafop + metsulfuron (60 + 4 g/ha), mesosulfuron + iodosulfuron (24 + 4.8 g/ha), mesosulfuron + iodosulfuron (18 + 3.6 g/ha) and metsulfuron 6 g/ha. 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 effects on both grassy and non-grassy weeds. Balyan and Malik (2000) recorded more or less similar yield to weed-free with the application of metsulfuron (4 and 6 g/ha) at Hisar. The performance of 2,4-D at 750 g/ha, sulfosulfuron at 25 g/ha, clodinafop at 60 g /ha, isoproturon at 1,000 g/ha and mesosulfuron + iodosulfuron (12 + 2.4 g/ha) application were statistically similar in producing grain, straw and biological yields. These results confirm the findings of Singh *et al.* (2003) and Bharat *et al.* (2012).

Nutrients (NPK) uptake

Mean data of 2 years showed that all weed-control treatments brought significant variation in nutrients uptake by wheat compared with weedy check (Table 3). Weed-free condition resulted in the highest nutrients (NPK) uptake by crop. However, it remained statistically at par with sulfosulfuron + metsulfuron (20 + 4 g/ha), clodinafop + metsulfuron (60 + 4 g/ha) and mesosulfuron + iodosulfuron (24 + 4.8 g/ha). Among the herbicidal treatments, tank mix application of sulfosulfuron + metsulfuron (20 + 4 g/ha) recorded the highest NPK uptake by wheat. However, it remains at par with clodinafop

Table 3. Effect of different weed-management methods on total NPK removal by crops and weeds in wheat (mean data of 2 years)

Treatment	NPK removal by weeds (kg/ha)			NPK removal by wheat (kg/ha)		
	N	P	K	N	P	K
Meso + iodo (12 + 2.4 g/ha)	9.91	2.41	9.61	96.26	13.68	93.48
Meso + iodo (18 + 3.6 g/ha)	2.16	0.58	1.47	138.8	18.39	116.69
Meso + iodo (24 + 4.8 g/ha)	2.12	0.56	1.40	142.4	18.90	117.23
Sulfosulfuron (25 g/ha)	14.73	3.07	14.45	108.4	16.17	104.89
Metsulfuron (6 g/ha)	7.82	2.03	5.51	121.8	17.33	114.71
Clodinafop (60 g/ha)	16.64	3.48	19.11	95.05	14.29	97.43
Sulf + met (20 + 4 g/ha)	2.46	0.67	2.33	148.0	19.55	122.7
Clodi + met (60 + 4 g/ha)	2.51	0.65	2.42	142.5	19.05	117.70
Isoproturon (1,000 g/ha)	19.81	4.14	19.59	102.0	13.86	99.08
2,4-D (750 g/ha)	10.33	2.96	9.33	101.85	16.33	109.87
Weedy check	37.72	7.63	43.14	50.55	7.530	52.78
Weed-free	0.00	0.00	0.00	150.8	19.94	125.01
SEm±	0.49	0.12	0.59	3.78	0.580	3.97
CD (P=0.05)	1.44	0.35	1.72	11.2	1.72	11.64

Meso, Mesosulfuron; Iodo, iodosulfuron; Sulfo, sulfosulfuron; Clodi, clodinafop; Met, metsulfuron

+ metsulfuron (60 + 4 g/ha), mesosulfuron + iodosulfuron (24 + 4.8 g/ha) and mesosulfuron + iodosulfuron (18+3.6 g/ha). Higher NPK uptake by crops in hand-weeded or herbicide-treated plots was reported by Pandey *et al.* (2000). This was due to reduced depletion of nutrients by weeds and concomitant increase in the absorption and translocation of higher concentration of these nutrients to different wheat plant parts for enhanced photosynthetic efficiency. Application of isoproturon at 1,000 g/ha and clodinafop at 60 g/ha resulted in relatively less uptake of NPK amongst herbicidal treatments.

On basis of the above results it is concluded that tank-mix application of sulfosulfuron + metsulfuron (20 + 4 g/ha), is advisable for reducing the weed pressure and obtaining the higher grain yield of wheat.

REFERENCES

Azad, B.S. 2003. Efficacy of herbicides for controlling weeds in wheat with special reference to *Phalaris minor*. *Annals of Plant Protection Sciences* **11**(1): 119–22.

Balyan R.S. and Malik, R.K. 2000. New herbicides for jangali palak (*Rumex retroflexus* L.). *Indian Journal of Weed Scienc*e **32**(1 and 2): 86–88.

Balyan, R.S. 1999. Efficiency of sulfosulfuran, tralkoxydim and metribuzin applied alone and tank-mix on weeds in wheat. *Indian Journal of Weed Science* **31**(122): 80–83.

Bharat, R., Kachroo, D., Sharma, R., Gupta, M. and Sharma, A.K. 2012. Effect of different herbicides on weed growth and yield performance of wheat. *Indian Journal of Weed Science* **44**(2): 106–09.

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

Kanojia, Y. and Nepalia, V. 2006. Effect of chemical weed control on nutrient uptake by wheat and associated weeds. *Agricultural Science Digest* **26**(2): 141–43.

Malik, R.K. and Malik, V.S. 1994. Development of herbicides resistance in India. (In) *Appropriate Weed Control in Southern Asia,* pp. 64–81. Sustroutone, S.S. and Bruce, A. Avid (Eds), CAB International.

Paighan, V.B. Gore, A.K. and Chavan, A.S. 2013. Effect of new herbicides on growth and yield of wheat. *Indian Journal of Weed Science* **45**(4): 291–93.

Pandey, I.B., Thakur, S.S., Singh, S.J., and Mishra, S.S. 2000. Effect of fertilizer and weed management on nutrient economy and yield of wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **45**(3): 596–601.

Singh, S., Singh, A.N. and Bhan, V.M. 1997. Studies on the chemical weed control in wheat. *Indian Journal of Weed Science* **29**(3 and 4): 100–102.

Singh, S., Malik, R.K., Singh, D. and Narwal, S. 2003. Evaluation of ready-mix of mesosulfuron + iodosulfuron for weed control in wheat. *Indian Journal of Weed Science* **35**(3 and 4): 190–93.

Ziveh, P.S. and Mahdavi, V. 2012. Evaluation of the effectiveness of different herbicides on weed invasion in the fields of triticale. *Journal of Plant Protection Research* **52**(4): 435–39.