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Management of diverse weed flora of wheat by herbicide combinations

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ABSTRACT

A field experiment was conducted at College of Agriculture, Gwalior, India during *Rabi* (winter) seasons of 2014-15 and 2015-16 to evaluate the bio-efficacy of different herbicides to control diverse weed flora especially *Phalaris minor* in wheat. The experiment was laid out in a randomized complete block design, replicated three times, and consisted of 12 treatments including four treatment as pendimethalin (0.75 kg/ ha) as pre-emergence (PE); sulfosulfuron (0.025 kg/ha), metribuzin (0.21 kg/ha), clodinafop (0.06 kg/ha) as post-emergence (PoE) used individually and six of different herbicidal combinations as pendimethalin + metribuzin (1.0 + 0.175 kg/ ha PE), pendimethalin + sulfosulfuron (1.0 + 0.018 kg/ha PE and PoE), sulfosulfuron + metsulfuron (0.03 + 0.002 kg/ha at 5 WAS), pinoxaden + metsulfuron (0.06 + 0.004 kg/ha at 5 WAS), mesosulfuron + iodosulfuron(0.012 + 0.0024 kg/ha at 5 WAS), clodinafop + metsulfuron (0.06 + 0.004 kg/ha at 5 WAS), weedy check and as two hand weedings at 30 and 60 DAS. The highest mortality of weeds and the maximum grain yield of 5.00 t/ha and 4.07 t/ha with 38.2%, 31.0% increase in grain yield over weedy check were recorded with two hand weedings at 30 and 60 DAS (weed free) followed by herbicidal combination as pinoxaden + metsulfuron (0.06 + 0.004 kg/ha at 5 WAS) as PoE application during 2014-15 and 2015-16, respectively. Whereas, the highest B:C ratio of (3.69) was obtained with pinoxaden + metsulfuron (pre-mix) followed by sulfosulfuron + metsulfuron (3.67).

Key words: Chemical control, Hand weeding, Herbicide combinations, Weed flora, Wheat

Wheat (*Triticum aestivum* L.) occupies about 17% of the world's cropped land and contributes 35% of the staple food and 20% of the calories (Anonymous 2002). In India, it has been a staple food for a large population and its continued production is essential for food security. It is grown in an area of about 31.0 million hactares with production and productivity of 88.9 million tones and 2.87 t/ha, respectively (DES, 2015). Weeds are one of the main problems to maintaining wheat production and productivity levels. The estimated yield loss worldwide caused by weeds varied between 7.7 to 23.9% depending on the region (Kosina *et al.* 2007). Wheat is infested with diverse weed flora, as it is grown in diverse agro-climatic conditions, under different cropping sequence, tillage and irrigation regimes (Chhokar *et al.* 2012). If the weeds are not controlled at the critical stages of crop growth, they may cause reduction in yield up to 66% (Kumar *et al.* 2011). For controlling weeds in wheat, growers mostly rely on herbicides due to cost and time effectiveness. To control diverse weed flora in wheat effectively, different herbicidal combinations are required (Singh *et al.* 2015). The grain yield of wheat is significantly increased by use of different chemicals for weed control as compared with weedy check (Chaudhry *et al.* 2008). For the past few decades, several herbicides have been employed for weed management in wheat. The development of herbicide resistance by certain weeds like *Phalaris minor* is mainly due to the use of single herbicides over a long period. Hand weeding though considered being the most effective weed management tool but it is never an economical weed control method (Akhtar *et al.* 2000). Though the chemical method is being discouraged worldwide, however, its immediate effect and economic returns cannot be ignored totally by the farmers of countries like India. Instead, the ill effects of herbicides can be minimized through their judicious use at recommended doses. Therefore, the present investigation was undertaken to evaluate different weed management practices and the bioefficacy of herbicides against complex weed flora and their effect on productivity and profitability of wheat.

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MATERIALS AND METHODS

A field experiment was carried out at the research farm of Department of Agronomy, RVSKVV, College of Agriculture, Gwalior during *Rabi* seasons of 2014-15 and 2015-16. The soil contained 0.51% organic carbon with the pH of 7.8 and electrical conductivity 0.34 dS/m in the top 15 cm of soil. The initial N (191.2 kg/ha) content of soil was low, P (12.3 kg/ha) content in soil was

marginally low and K (206 kg/ha) was medium with sandy clay loam in texture. The experiment was laid out in a randomized complete block design, replicated three times, and consisted of twelve treatments including four treatment as pendimethalin (0.75 kg/ ha) as pre-emergence, sulfosulfuron (0.025 kg/ha), metribuzin (0.21 kg/ha), clodinafop (0.06 kg/ha) as post-emergence used individually and six of different herbicidal combinations as pendimethalin + metribuzin (1.0 + 0.175 kg/ha PE), pendimethalin + sulfosulfuron (1.0 + 0.018 kg/ ha PE and PoE), sulfosulfuron + metsulfuron (0.03 + 0.002 kg/ha at 5 WAS), pinoxaden + metsulfuron (0.06 + 0.004 kg/ha at 5 WAS), mesosulfuron + iodosulfuron (0.012 + 0.0024 kg/ha at 5 WAS), clodinafop + metsulfuron (0.06 + 0.004 kg/ha at 5 WAS), one kept weedy check for comparison and one cultural practice of weed control as two hand weedings at 30 and 60 DAS.

Wheat variety '*MP 4010*' was sown in rows 20 cm apart on 3rd December 2014 and harvested on 28th march 2015. The recommended dose of NPK was 120:60,:40 kg/ha and were supplied by urea, DAP and MOP, respectively. The full dose of P and K and half dose of N were applied at the time of sowing, whereas rest of the N was given in two equal splits one as top dressed at crown root initiation and another at late jointing stage of the crop. Irrigation was applied at all the critical stages of crop growth during the experimentation. Herbicides were applied at appropriate rate and suitable timings with the help of knapsack sprayer with flat-fan nozzle at spray volume of 600 liters water/ha. Observations on weed density and dry matter of weeds were recorded from 1.0 m^2 quadrate in each plot to determine species wise weed density and dry weight of weeds at 60 DAS. Statistical analysis of the data was carried out using analysis of variance technique as applicable to RCBD (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on weeds

The complex weed flora of the experimental field comprised of grassy weeds as *Phalaris minor*, *Cyperus rotundus* and broad-leaved weeds as *Chenopodium album*, *Spergula arvensis*, *Convolvulus arvensis* during both the years of experimentation. *Rumex dentatus* was observed only in 2014-15 but was washed out from field during next year of experimentation. During 2015-16 in addition to above mentioned weeds, *Anagalis arvensis* was also observed.

In general, the weed density in the experimental field was less, it may be because the initial flush of weeds in the field was destroyed due to ploughing at the time of field preparation. All weed control treatments significantly reduced the weed density of *Phalaris minor* and *Chenopodium album* during 2014-15 and *P. minor* and *C. album*, *Cyperus rotundus*, *Spergula arvensis*, *Convolvulus arvensis* and *Anagalis arvensis* during 2015-16. While density of *C. rotundus*, *S. arvensis*, *C. arvensis* and *Rumex dentatus* was not reduced by any treatment significantly during 2014-15 and *A. arvensis* during 2015-16.

All the treatments reduced the dry weight of weeds significantly as compared to weedy check. The lowest weed dry weight was recorded in cultural method of weed control where two hand weedings were done at 30 and 60 DAS. The highest weed control efficiency of 91.74 and 93.31% was recorded with two hand weedings at 30 and 60 DAS during 2014-15 and 2015-16, respectively. It was followed by the herbicide combinations as mesosulfuron + idosulfuron (87.61%) during 2014-15 and by pinoxaden + metsulfuron (89.75%) during 2015-16. The treatments where sulfosulfuron applied individually gave highest WCE of 79.82% and 80.01% during 2014-15 and 2015-16, respectively. It is mainly because sulfosulfuron is a selective, systemic sulfonyl urea herbicide, absorbed through both roots and leaves. It translocates throughout the plant and acts as an inhibitor of amino acid biosynthesis, hence stopping cell division and plant growth.

The weed control efficiency under clodinafop was lesser than that of different other treatments during both the years.The total weed density during 2014-15 was lowest where sulfosulfuron and metsulfuron were applied conjointly and the weed management practice where two hand weedings were done at 30 and 60 DAS resulted in reduced weed density during 2015-16. Two hand weeding at 30 and 60 DAS resulted in highest weed control efficiency (91.7 and 93.3%) followed by the herbicidal combinations of mesosulfuron + iodosulfuron (87.6%) during 2014-15 and pinoxaden + metsulfuron (89.7%) during 2015-16. Among alone application of herbicidal treatments, application of sulfosulfuron 0.025 kg/ha resulted in efficient weed control of 79.8 and 80.0 during 2014-15 and 2015-16, respectively.

Effect on crop

The plant height of wheat crop was not influenced significantly under different weed

management treatments during both the years of experimentation. No visual phytotoxic effect was observed on crop due to application of herbicide either individually or in combinations, except combined application of sulfosulfuron and metsulfuron. During initial growth period of crop, the application of sulfosulfuron in combination with metsulfuron (0.03 + 0.002 kg/ha) had influenced the crop adversely which was recovered within 10 -15 days after herbicidal treatment application.

Number of tillers, length of ear head and number of grains/ear were found the highest under two hand weedings done at 30 and 60 DAS which was at par with pinoxadon + metsulfuron (0.06 + 0.004 kg/ha). The number of grains/ear was the highest with mesosulfuron + iodosulfuron (0.012 + 0.0024 kg/ha as PoE). Among the individual herbicides, sulfosulfuron resulted in the highest number of grains/ear during 2014-15, and during 2015-16 clodinafop resulted the best. The highest grain yield of 5.03 t/ha was achieved with two hand weeding and was at par with sulfosulfuron + metsulfuron and mesosulfuron + iodosulfuron. Sulfosulfuron alone gave significantly the highest grain yield during 2014-15. Among various herbicidal combinations, application of pinoxaden and metsulfuron conjointly resulted in significantly the highest straw yield over weedy check.

Economics

All the weed control treatments were significantly superior over weedy check in terms of monetary returns during both the years. The highest net income and B:C ratio (` 71182/ha and 3.69) were fetched under pinoxaden + metsulfuron during 2014-15, but sulfosulfuron + metsulfuron (` 79296/ha and 3.14) resulted in the highest net returns and B C ratio during 2015-16. Alone application of sulfosulfuron 0.025 kg/ha resulted in the highest net returns and B C ratio (` 55353/ha, ` 48141/ha and 3.11, 2.84) during 2014-15 and 2015-16, respectively.

It has been concluded that application of metsulfuron in combination with sulfosulfuron and pinoxaden resulted in better weed control, higher crop yields and benefits .

Table 1. Effect of different herbicides and their combinations on weed population (no/m^2) in wheat (mean of 2014-15 and 2015-16)

Treatment	*Phalaris minor*		*Cyperus rotundus*		*Chenopodium album*		*Spergula arvensis*		*Convolvulus arvensiss*		*Rumex dantatus*	*Anagallis arvensis*	Total weeds	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Pendimelhalin 0.75 kg/ha PE	0.43 (2.33)	1.14 (13.0)	1.29 (18.67)	1.37 (24.33)	0.95 (8.00)	1.43 (27.33)	1.50 (3.00)	1.56 (2.00)	0.71 (0.00)	0.88 (0.33)	1.29 (1.33)	0.71 (0.00)	1.56 (33.33)	6.09 (67.00)
Sulfosulfuron 0.025 kg/ha PoE	0.00 (0.00)	0.40 (1.67)	1.41 (26.00)	1.11 (12.00)	0.36 (1.67)	1.19 (15.33)	1.05 (0.67)	1.34 (1.33)	0.88 (0.33)	0.71 (0.00)	0.71 (0.00)	1.17 (1.0)	1.38 (28.67)	5.63 (31.33
Metribuzin 0.210 kg/ha PE	0.54 (3.67)	1.07 (12.0)	1.43 (26.00)	1.68 (20.67)	0.16 (0.67)	1.22 (16.33)	0.71 (0.00)	1.64 (2.33)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.29 (1.33)	1.47 (30.33)	7.28 (52.67)
Clodinafop 0.060 kg/ha PoE	0.88 (7.00)	0.57 (3.0)	1.48 (29.67)	1.33 (21.00)	0.00 (0.00)	1.35 (22.00)	0.71 (0.00)	1.17 (1.00)	1.25 (1.67)	1.29 (1.33)	1.10 (1.00)	1.65 (2.67)	1.55 (39.33)	7.17 (51.00)
Pendimelhalin + metribuzin 1.0 + 0.175 kg/ha PE	0.16 (0.67)	0.85 (6.33)	1.36 (24.00)	1.14 (15.33)	0.00 (0.00)	1.42 (26.00)	1.25 (1.67)	1.56 (2.00)	0.88 (0.33)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.45 (26.67)	7.02 (49.67)
Pendimelhalin *fb* sulfosulfuron 1.0 + 0.018 kg/ha PE and PoE	0.00 (0.00)	0.72 (4.67)	1.34 (33.33)	0.99 (9.33)	0.26 (1.67)	0.78 (5.66)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.00 (0.67)	0.71 (0.00)	1.55 (35.67)	5.38 (29.33)
Sulfosulfuron + metsulfuron (total) 0.02 + 0.002 kg/ha PoE	0.00 (0.00)	0.16 (0.67)	1.18 (14.33)	0.71 (4.67)	0.00 (0.00)	1.20 (16.33)	0.88 (0.33)	0.88 (0.33)	0.71 (0.00)	0.88 (0.33)	0.71 (0.00)	1.68 (2.33)	1.15 (14.67)	3.78 (14.00)
Pinoxaden + metsulfuron (premix) 0.06 + 0.004 kg/ha PoE	0.00 (0.00)	0.52 (2.67)	1.30 (20.33)	0.95 (8.00)	0.51 (3.33)	1.04 (10.33)	0.71 (0.00)	1.29 (1.33)	1.00 (0.67)	1.00 (0.67)	0.71 (0.00)	1.74 (2.67)	1.40 (24.33)	5.65 (31.67)
Mesosulfuron + iodosulfuron (atlantis) 0.012 + 0.0024 kg/ha PoE	0.00 (0.00)	0.32 (1.33)	1.29 (20.00)	0.87 (6.67)	0.00 (0.00)	1.14 (13.33)	0.71 (0.00)	1.00 (0.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.17 (1.00)	1.26 (20.00)	4.52 (20.00)
Clodinafop + metsulfuron (vesta) 0.06 + 0.004 kg/ha PoE	0.30 (2.33)	0.42 (1.67)	0.93 (16.00)	0.93 (7.67)	0.76 (5.00)	1.30 (59.0)	0.71 (0.00)	1.34 (1.33)	0.71 (0.00)	0.88 (0.33)	0.71 (0.00)	1.00 (0.67)	1.33 (23.33)	5.05 (25.00)
Two hand weedings at 30 and 60 DAS	0.00 (0.00)	0.00 (0.0)	1.20 (15.67)	0.74 (5.00)	0.23 (1.33)	0.36 (1.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.88 (0.33)	0.71 (0.00)	0.71 (0.00)	1.28 (17.00)	2.71 (7.00)
Weedy check	1.82 (66.67)	1.78 (59.3)	1.80 (63.33)	1.68 (49.00)	1.68 (47.67)	1.69 (51.00)	1.64 (2.67)	2.24 (4.67)	1.44 (2.67)	1.76 (2.67)	1.64 (2.67)	1.86 (3.0)	2.30 (185.7)	13.04 (169.7)
LSD (p=0.05)	0.44 Log x+1	0.32 $\sqrt{x+0.5}$	NS Log x+1	0.32 Log x+1	0.42 Log x+1	0.34 Log x+1	NS $\sqrt{x+0.5}$	0.62 $\sqrt{x+0.5}$	NS $\sqrt{x+0.5}$	0.48 $\sqrt{x+0.5}$	NS $\sqrt{x+0.5}$	0.69 $\sqrt{x+0.5}$	0.18 Log x	2.29 Log x

Original values given in parentheses were subject to square root transformation

Table2. Effect of different herbicides and their combinations on growth, yield attributes and economics of wheat during 2014-15 and 2015-16

Treatment	Plant height (cm)		No. of tillers/plant		Ear head length (cm)		No. of grains/ear		Grain yield (t/ha)		Straw yield (t/ha)		Dry weight (g/m^2) 60 DAS		WCE (%)		B.C. Ratio	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Pendimelhalin 0.75 kg/ha PE	91.1	90.8	4.27	3.87	8.83	8.73	47.3	51.0	3.50	3.19	5.05	4.77	64	76.0	70.6	63.5	2.63	2.41
Sulfosulfuron 0.025 kg/ha PoE	90.6	90.6	5.00	4.83	9.77	9.67	52.0	53.1	4.19	3.80	5.52	5.09	44	32.7	79.8	80.0	3.11	2.84
Metribuzin 0.210 kg/ha PE	93.7	93.7	4.20	4.30	8.77	9.00	50.0	52.7	3.50	3.26	5.03	4.79	84	50.7	61.5	64.9	2.66	2.51
Clodinafop 0.060 kg/ha PoE	93.7	94.0	4.00	4.67	8.70	8.90	51.7	54.0	3.74	3.51	5.38	4.99	65	35.0	70.2	73.9	2.80	2.64
Pendimelhalin + metribuzin 1.0 + 0.175 kg/ha PE	92.9	94.5	4.40	4.60	9.40	9.93	52.3	52.7	3.93	3.58	5.35	4.81	71	50.0	67.4	68.5	2.82	2.56
Pendimelhalin *fb* sulfosulfuron 1.0 + 0.018 kg/ha PE and PoE	89.0	89.1	5.13	4.93	9.57	9.43	55.1	52.0	4.26	3.70	6.15	5.09	78	42.0	64.2	68.7	3.10	2.69
Sulfosulfuron + metsulfuron (total) 0.03 + 0.002 kg/ha PoE	92.9	94.4	5.37	4.93	9.97	9.70	55.3	55.7	4.96	4.20	6.51	5.19	30	17.0	86.2	87.7	3.67	3.14
Pinoxaden + metsulfuron (premix) 0.06 + 0.004 kg/ha PoE	92.0	92.8	5.53	4.83	10.13	9.30	53.7	55.3	5.00	4.07	6.74	5.23	28	11.3	87.1	89.7	3.69	2.99
Mesosulfuron + iodosulfuron (atlantis) 0.012 + 0.0024 kg/ha PoE	94.5	90.2	5.30	5.00	10.10	9.40	56.7	56.0	4.91	4.00	6.70	5.01	27	17.7	87.6	88.4	3.53	2.91
Clodinafop + Metsulfuron (vesta) 0.06 + 0.004 kg/ha PoE	93.7	92.2	5.33	4.80	9.93	9.23	55.7	55.7	4.56	3.80	6.52	5.14	39	18.0	82.1	85.1	3.41	2.82
Two hand weedings at 30 and 60 DAS Weed free)	94.6	90.6	5.40	5.13	10.47	9.57	56.0	55.3	5.03	4.30	6.74	5.16	18	7.7	91.7	93.3	2.98	2.56
Weedy check	86.1	89.9	3.40	3.30	7.87	7.90	37.0	41.3	3.09	2.81	4.80	4.22	218	165.7	-	-	2.44	2.19
LSD (p=0.05)	NS	NS	0.66	0.68	0.64	0.88	5.91	6.02	0.26	0.53	0.30	0.95	73	22.72		-	-	-

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