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Efficacy of Isoproturon and Pendimethalin against Resistant Biotypes of *Rumex* spp. in Wheat (*Triticum aestivum* L.)

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***Abstract*:** Persistence of weeds under irrigation conditions is inevitable and manual management practices are labour intensive and cumbersome. As far as wheat is concerned huge losses in yield, are incurred due to *Rumex* spp. Therefore, the present study was carried out to evaluate the efficacy of herbicides against *Rumex* spp. during the *Rabi,* 2017-18 at Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana). Isoproturon as post- emergence and pendimethalin as pre-emergence were taken as treatments and applied at three doses (0.5X, 1.0X and 2.0X) under pot study 'X' is the recommended dose of herbicide@ 1000g/ha for isoproturon and 1500g/ha for pendimethalin .Four populations of *Rumex* spp. named as HHH (HAU Hisar), UPH (Ujha, Panipat), JHH (Jind) and JJR (Jhajjar) collected from putative resistance affected farmer's field.UPH and JHH populations are highly resistant whereas JJR population is moderately resistant to sulphonylureas herbicides. HHH population is sensitive so used as standard check for comparison. Majority of biotypes showed sensitivity against isoproturon at recommended dose except UPH biotype. It provided 70-90 per cent control to all biotypes at double of recommended doses. Lower values of plant height, chlorophyll fluorescence, fresh and dry weight were observed in isoproturon treated plants. *Rumex* biotypes were highly sensitive to pendimethalin when applied as pre emergence. It provided complete control to all biotypes. The information collected from this study will facilitate proactive management of *Rumex* spp. through sequential application of pre and post emergence herbicides.

***Keywords*:** Biotype**,** chlorophyll fluorescence*,* isoproturon, pendimethalin*, Rumex* spp.

Wheat (*Triticum aestivum*) is world's most widely cultivated and leading staple food crop with an area, production and productivity of 214.3 mha, 734.1 mt and 3425.5 kg/ha, respectively (FAO STAT 2018). In India, it is the second most important food crop after rice cultivated in 30.6 mha with 99.8 mt production and 3220 kg/ha productivity (Anonymous 2018). Haryana is the major wheat growing state of India with an area of about 2.53 m ha with 11.7 mt production and 4.62 t/ha productivity (Anonymous 2018a). Weeds are a major impediment to crop production through their ability to compete for light, moisture, nutrients and space (Singh et al 2007). Weeds are a serious cause of concern for wheat productivity loss to the tune of 15-40 per cent or even higher besides lowering down the quality of produce (Chopra et al 2001). Extent of yield loss depends upon type and density of weed, soil characteristics and environmental conditions (Chhokar and Malik 2002). Weed stage, herbicide rates and fertilizers application impact weed control and crop-weed competition. Wheat is infested with diverse weed flora because it is grown in diverse agro-climatic conditions, under different cropping sequences, tillage and irrigation regimes . *Rumex dentatus, Chenopodium album, Medicago sativa, Melilotus alba* and *Fumaria parviflora* are major broad leaf weeds in rice-wheat cropping system (Chhokar et al 2006). Reduced tillage or no till wheat with higher moisture in rice–wheat system favours the infestation of broad leaf weeds like *Malwa parviflora* and *R. dentatus.* Worldwide herbicide is a key tool of weed management in wheat due to its cost and time effectiveness. *R. dentatus* is a major broadleaf weed of *rabi* season and is a serious problem of irrigated wheat particularly in rice-wheat cropping system in north-western Indo-Gangetic alluvial plains of India (Sandhu and Dhaliwal 2016). This weed is highly competitive and yield losses up to 55 per cent have been reported (Heap 2014). Metsulfuron, a sulfonylurea herbicide was recommended for its control in wheat during 1998. But recently, poor efficacy of metsulfuron against the toothed dock (*R. dentatus* L.) was observed under field conditions and the subsequent studies confirmed the instances of herbicide resistance in this weed (Singh et al 2017). Herbicide resistant weeds in wheat crop were susceptible to pre emergence (PRE) herbicides such as pendimethalin, and metribuzin (Chhokar and Sharma 2008). But alone pre-emergence herbicides are not effective against *Rumex* spp.So there is need to evaluate the alternate pre and post emergence herbicides for effective management of *Rumex* spp.

MATERIAL AND METHODS

The experiment was conducted during *rabi* season of 2017-18 in screen house, Chaudhary Charan Singh Haryana Agricultural University, Hisar with latitude and longitude of 29°9"14' and 75°43"22', respectively. The maximum and minimum weekly mean temperatures of 35.7°C and, 2.6°C were recorded during 2nd, 13th and 14th standard meteorological week. The total rainfall during the crop season was 15.9 mm. The average annual rainfall ranged between 500-750 mm. Isoproturon and pendimethalin were applied at three doses (0.5X, 1.0X and 2.0X) named as in pot experiment under completely randomized design with three replications. Here 'X' is recommended dose of herbicides whose value is 1500 g/ha for pendimethalin and 1000g/ha for isoproturon. Seeds of four populations of *Rumex* spp. named as HHH (HAU Hisar), UPH (Ujha, Panipat), JHH (Jind), and JJR (Jhajjar) were collected from putative resistance affected farmer's fields. HAU population was a standard sensitive population for comparison. Soil was taken from Agronomy Research Farm area for filling the pots, which was free from seeds of *Rumex* spp. and not exposed to herbicides from the last two years. The soil was air-dried, well crushed in fine particles to pass through a sieve of 2 mm pore size. Plastic pots (6″ diameter) were filled with 2 kg material comprising sand and vermi-compost was mixed with field soil in such a way that sand, field soil and vermi-compost are in ratio of (2:3:1). Plant height, chlorophyll fluorescence, mortality percentage, electrical conductivity, fresh weight and dry weight were recorded as parameters. All the observations were statistically analyzed by using software OP STAT.

RESULTS AND DISCUSSION

Plant height: Significant variation in plant height of *Rumex* biotypes was observed at 2 and 4 weeks after treatment (WAT) with application of isoproturon (Table 1). The isoproturon doses, significantly affected plant height. The higher plant height (cm) was recorded in UPH and JHH (22.8) followed by HHH and JJH at 2 WAT. The significantly higher plant height was observed in UPH (22.2) which was statistically similar with JHH (21.6) but significantly higher than other biotypes at 4 WAT. Isoproturon @ 500 and 1000 g/ha resulted statistically similar plant height among all biotypes except HHH at 2 and 4 WAT. Half dose of isoproturon resulted in 5.3 per cent and 8 per cent higher plant height over recommended dose, whereas double dose resulted in 5.3 per cent and 8.6 per cent lower plant height than recommended dose, respectively at 2 and 4 WAT. Non-significant variation in plant height of *Rumex* biotypes was observed at spraying, 2 and 4 WAT with the application of pendimethalin. It is due to zero emergence of *Rumex* spp. plants caused by pre-emergence spray of pendimethalin.

Plant chlorophyll: *Rumex* biotypes as affected by the application of isoproturon at 1, 2 and 7 days after treatment (DAT) (Table 2). The significantly higher plant chlorophyll fluorescence (Fv/Fm) was observed in UPH (0.42-0.41-0.37) followed by JHH, HHH and JJH respectively at 1, 2 and 7 DAT. Half dose of isoproturon resulted in 142.0, 180.0 and 360.0 per cent higher plant chlorophyll fluorescence over recommended dose, whereas double dose resulted in 16.7, 20 and 40 per cent lower plant chlorophyll fluorescence than recommended dose, respectively at 1, 2 and 7 DAT, when data was averaged over all biotypes.Non-significant variation in plant chlorophyll fluorescence of *Rumex* biotypes was observed by the application of pendimethalin at 1 and 2 DAT. It is due to zero emergence of *Rumex* plants caused by pendimethalin spray.

Table 1. Plant height of *Rumex* biotypes as influenced by isoproturon (g/ha)

Populations	Plant height week after treatment (cm)														
	Before spraying					2					4				
	0	500	1000	2000	Mean	0	500	1000	2000	Mean	0	500	1000	2000	Mean
HHH	18.3	17.3	17.0	17.3	17.5	25.7	19.3	18.0	16.7	19.9	26.3	18.7	17.0	15.7	19.4
UPH	19.0	18.3	18.3	18.0	18.4	26.7	23.7	21.7	19.3	22.8	27.3	22.7	20.3	18.3	22.2
JHH	18.0	17.0	17.0	17.0	17.3	27.0	22.0	21.0	21.0	22.8	27.7	21.0	20.0	17.7	21.6
JJH	17.0	16.3	16.3	16.0	16.4	21.0	14.3	14.3	14.3	16.0	21.7	12.7	12.3	12.0	14.7
Mean	18.1	17.3	17.2	17.1		25.1	19.8	18.8	17.8		25.8	18.8	17.4	15.9	
				CD (P=0.05)					CD (P=0.05)					CD (P=0.05)	
Population				0.9					0.7					0.8	
IPU				NS					0.7					0.8	
Population x IPU				NS					1.4					1.5	

IPU, isoproturon; WAT, weeks after treatment

Weed control: The control of *Rumex* biotypes significantly varied with the application of isoproturon at 1, 2 and 4 WAT (Table 3). Significantly lower mortality (%) was recorded in UPH (35-42-45) followed by JHH,HHH and JJH at 1, 2 and 4 WATduring. The per cent mortality of HHH was f statistically similar with JHH at 1, 2 and 4 WAT. Half dose of isoproturon resulted in 13.1-15.7-10.4 per cent lower mortality over recommended dose, whereas double dose resulted in 11.5-8.6-10.4 per cent higher mortality than recommended dose, respectively at 1, 2 and 4 WAT.Per cent control of *Rumex* biotypes was non-significant with the application of pendimethalin at 1, 2 and 4 WAT as there is no emergence of *Rumex* plants due to pendimethalin effect.

Electrical conductivity (EC): Isoproturon had significant effect on EC of *Rumex* biotypes, before and after boiling the plant solution at 1 WAT (Table 4). Significantly lower EC (ds/m) was in UPH (0.13-0.25) followed by JHH , HHH and JJH t before and after boiling at 1 WAT. Half dose of isoproturon resulted in 13.6-13.6 per cent lower EC over recommended dose, whereas double dose resulted in 13.6-11.4 per cent higher EC than recommended dose, respectively before and after boiling at 1 WAT. Pendimethalin had non-significant effect on EC of *Rumex* biotypes, before and after boiling at 1 WAT as there is no emergence of *Rumex* plants due to pendimethalin action.

Fresh and dry weight: The isoproturon doses, significantly higher fresh weight (g/pot) was recorded in UPH (4.01) followed by JHH, HHH and JJH whereas significantly higher dry weight (g/pot) was recorded in UPH (1.49) followed by JHH , HHH and JJH at harvesting (120 DAS) (Table 5). Mean fresh and dry weight in JHH was statistically similar with HHH. Isoproturon @ 1000 and 2000 g/ha resulted in statistically similar fresh and dry weight among all biotypes except UPH at harvesting (120 DAS). Half dose of isoproturon resulted in 45.3 per cent and 51.2 per cent higher fresh and dry weight, respectively over recommended dose,

Table 2. Plant chlorophyll fluorescence (Fv/Fm) of *Rumex* biotypes as influenced by isoproturon (g/ha)

Populations	Chlorophyll fluorescence days after treatment (Fv/Fm)														
	1					2					7				
	0	500	1000	2000	Mean	0	500	1000	2000	Mean	0	500	1000	2000	Mean
HHH	0.85	0.13	0.11	0.09	0.30	0.85	0.11	0.09	0.07	0.28	0.85	0.06	0.04	0.02	0.25
UPH	0.91	0.53	0.13	0.12	0.42	0.91	0.51	0.11	0.10	0.41	0.91	0.46	0.06	0.04	0.37
JHH	0.91	0.39	0.13	0.10	0.38	0.91	0.38	0.11	0.08	0.37	0.91	0.33	0.06	0.04	0.33
JJH	0.84	0.12	0.10	0.08	0.29	0.84	0.10	0.08	0.06	0.27	0.84	0.05	0.03	0.01	0.23
Mean	0.88	0.29	0.12	0.1		0.88	0.28	0.10	0.08		0.88	0.23	0.05	0.03	
				CD (P=0.05)					CD (P=0.05)					CD (P=0.05)	
Population				0.2					0.2					0.2	
IPU				0.2					0.2					0.2	
Population x IPU				0.4					0.4					0.4	

IPU, isoproturon; DAT, days after treatment

Table 3. Per cent control of *Rumex* biotypes as influenced by isoproturon (g/ha)

Populations	Mortality week after treatment (%)														
	1					2					4				
	0	500	1000	2000	Mean	0	500	1000	2000	Mean	0	500	1000	2000	Mean
HHH	0	48	56	67	43	0	53	67	73	48	0	69	81	89	60
UPH	0	43	49	50	35	0	45	56	65	42	0	51	58	70	45
JHH	0	47	52	64	41	0	50	66	75	48	0	67	79	89	59
JJH	0	75	89	89	64	0	89	89	89	67	0	89	89	89	67
Mean	0	53	61	68		0	59	70	76		0	69	77	85	
				CD (P=0.05)					CD (P=0.05)					CD (P=0.05)	
Population				2.5					4.5					3.0	
IPU				2.5					4.5					3.0	
Population x IPU				5.0					9.0					6.0	

IPU,isoproturon; WAT, weeks after treatment

whereas double dose resulted in 53 per cent and 46.5 per cent lower fresh and dry weight, respectively than recommended dose at harvesting (120 DAS), over all biotypes.Non-significant variation in fresh and dry weight of *Rumex* biotypes was observed by the application of pendimethalin at harvesting time as there is no emergence of *Rumex* plants.

Majority of biotypes showed sensitivity against application of isoproturon at recommended dose and double of recommended dose except UPH biotype at 4 WAT. It provided 70-90 per cent control to all biotypes at double of recommended doses. Lack of mortality in *Rumex* biotypes at half of recommended dose and recommended dose could be due to lower availability of lethal dose of herbicide to translate in satisfactory control. These results are in the conformity with the findings earlier researchers (Sinha and Singh 2005, Khokhar and Charak 2011, Chhokar et al 2017). Low value of chlorophyll fluorescence was observed in all biotypes with the application of isoproturon is due to inhibition of photosystem II. These observations are supported by the findings of Varshney et al (2012). Kumar et al (2008) observed a significant decrease in Fv /Fm at 1 and 2 days after treatment (DAT) in herbicide treated plants. Kirkwood et al (2000) also reported similar findings and found that herbicide application caused large changes in Fv / Fm values after 1 day of application. *Rumex* biotypes were highly sensitive to pendimethalin, when applied as pre emergence. It provided complete control in all biotypes. No emergence was found in pots treated with pendimethalin even at half of the recommended dose of herbicide. It is due to mitotic disruption through inhibition of microtubule protein tubulin. These results are in conformity with findings of Patil and Dhonde (2009). Kaur et al (2017) also observed the good efficacy of pendimethalin against *Rumex* spp.

Table 4. EC of *Rumex* biotypes before and after boiling as influenced by isoproturon (g/ha) at 4weeks after treatment

Populations	EC (ds/m)									
	Before boiling the plant solution					After boiling the plant solution				
	0	500	1000	2000	Mean	0	500	1000	2000	Mean
HHH	0.01	0.17	0.21	0.26	0.17	0.02	0.34	0.43	0.53	0.33
UPH	0.02	0.14	0.17	0.18	0.13	0.03	0.28	0.34	0.36	0.25
JHH	0.02	0.16	0.19	0.24	0.15	0.03	0.33	0.39	0.49	0.31
JJH	0.01	0.28	0.30	0.30	0.22	0.03	0.57	0.60	0.6	0.45
Mean	0.02	0.19	0.22	0.25		0.03	0.38	0.44	0.49	
				CD (P=0.05)					CD (P=0.05)	
Population				0.01					0.02	
IPU				0.01					0.02	
Population x IPU				0.01					0.03	

EC, electrical conductivity; IPU, isoproturon; WAT, weeks after treatment

Table 5. Fresh and dry weight of *Rumex* biotypes as influenced by isoproturon at harvesting (120 DAS)

Populations	EC (ds/m)									
	Before boiling the plant solution					After boiling the plant solution				
	0	500	1000	2000	Mean	0	500	1000	2000	Mean
HHH	6.97	1.40	0.60	0.33	2.33	2.47	0.53	0.23	0.13	0.84
UPH	8.57	3.50	2.87	1.10	4.01	3.23	1.27	1.03	0.43	1.49
JHH	7.63	1.43	0.77	0.37	2.55	2.83	0.53	0.23	0.13	0.93
JJH	3.23	0.47	0.43	0.40	1.13	2.40	0.27	0.23	0.23	0.78
Mean	6.60	1.70	1.17	0.55		2.73	0.65	0.43	0.23	
				CD (P=0.05)					CD (P=0.05)	
Population				0.24					0.12	
IPU				0.24					0.12	
Population x IPU				0.49					0.25	

IPU, isoproturon; DAS, days after showing

CONCLUSION

Majority of *Rumex* biotypes showed sensitivity against isoproturon at recommended dose except UPH biotype. It provided 70-90 per cent control to all biotypes at double of recommended doses. *Rumex* biotypes were highly sensitive to pendimethalin when applied as pre emergence. It provided complete control in all biotypes. No emergence was found in pots sprayed with pendimethalin even at half of the recommended dose of herbicide. This is the key finding of this study because pre-emergence intervention with pendimethalin could resolve the problem of resistant *Rumex* biotypes being faced by the farmers without incurring extra cost of post-emergence herbicides.

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