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Research Paper

Wheat (*Triticum aestivum*) productivity as affected by application of low dose herbicides as sole and premix formulations

N.K. CHOPRA[1] AND NISHA CHOPRA[2]

Regional Station, Indian Agricultural Research Institute, Karnal, Haryana 132001

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ABSTRACT

A field experiment was conducted during winter season of 2006-07 and 2007-08 at Karnal to evaluate the effect of herbicides as sole and their premix formulations on weed control in wheat [*Triticum aestivum* (L.) Emend. Fiori and Paol]. Maximum average seed yield of 4.59 t/ha was recorded with premix clodinafop + metsulfuron at 60+4g/ha, which was at par with weed free treatment and 10.0 and 20.8% higher compared to sole application of clodinafop 60g/ha and metsulfuron 4g/ha respectively. Sole application of clodinafop 60g/ha was found effective only on grasses, whereas metsulfuron 4g/ha showed selectivity towards broadleaf weeds and both the treatments recorded lower weed control efficiency and higher weed index compared to premix formulations of clodinafop + metsulfuron at 45+3, 54+3.6and 60+4g/ha. Uncontrolled weeds caused 24.7% reduction in wheat yield. Maximum returns and benefit cost ratio was recorded with clodinafop+ metsulfuron 60+4g/ha.

Key words : Clodinafop, Economics, Formulations, Metsulfuron, Premix, Wheat

North western irrigated belt of India is in grip of serious menace of grassy and broadleaf weeds notably little canary grass (*Phalaris minor* Retz.), golden dock (*Rumex maritimus* L.), Indian sweet clover (*Melilotus indica* All. FI. Ped.), swine grass (*Coronopus didymus* L.), common lambs quarter (*Chenopodium album* L.), scarlet pimpernel b (*Anagalisarvensis* L.), bur clover (*Medicago denticulata* L.) and medov pea (*Lathyrus aphaca* L.).Weeds are a major impediment to crop production through their ability to compete for resources and their impact on product quality (Rao and Nagmani 2010) and causes yield reduction to the tune of 15-50% or sometimes more depending upon weed density and type of weed flora (Jat*et al.*, 2003) and makes the weed control more complex.

After the development of resistance in *Phalaris minor* against isoproturon, clodinafop- propargyl and fenoxaprop-p-ethyl were recommended to combat the resistant biotypes. These alternate herbicides have been found to be ineffective against the broadleaf weeds (Singh and Singh, 2005) resulting in build-up of *Rumex maritimus, Coronopus dydimus, Medicago denticulata, Anagallis arvensis, Lathyrus apacha and Melilotus indica.* New molecules of broadleaf herbicides like metsulfuron methyl and carfentrazone ethyl control the broadleaf weeds effectively but were less effective towards grassy weeds. To manage the dynamic and complex weed flora in wheat there is need to evaluate different herbicides alone and in mixtures to have a broad spectrum weed control. Keeping all these in view the present study was undertaken to assess the efficacy of herbicides and their mixtures on weeds and wheat. Premix formulation of different doses of clodinafop propargyl + metsulfuron methyl was supplied by Cheminova India Pvt. Ltd. Mumbai for evaluation against complex weed flora in wheat.

MATERIALS AND METHODS

Field experiment was conducted during winter seasons of 2006-07 and 2007-08 at Research farm of the Indian Agricultural Research Institute Regional Station Karnal (76^0Elongitude, $29^0$43'N latitude at 243 m above the mean sea level to evaluate the effect of herbicides and their mixture on weed control and wheat productivity. The soil of the experimental field was clay loam in texture with pH 7.9. The available N,P and K were 180, 21.2 and 300 kg/ha respectively. Eight treatments consisting of clodinafoppropargyl (60g/ha), metsulfuron methyl (4g/ha), clodinafop + metsulfuron (45+3g/ha), clodinafop + metsulfuron (54+3.6 g/ha), clodinafop + metsulfuron (60+4g/ha), clodinafop + metsulfuron (180+12 g/ha) weedy and weed free check were evaluated in randomized block design with four replications. Wheat 'HD 2329' was sown in rows 22.5cm apart on 24 and 27 November in

[1]Corresponding author (Email : nishaknl@gmail.com)
[1]Senior Scientist;[2]Principal Scientist

2006-07 and 2007-08 respectively. Recommended dose of fertilizers as 120kg N, 26.2 kg P and 33.3 kg K/ha in both the years were applied uniformly to all the plots. Total rainfall received during 2006-07 and 2007-08 was 300.9 and 5.4mm respectively and crop received three and six post sowing irrigations respectively during the crop season. Herbicides were sprayed using a spray volume of 500 liters/ha with a knapsack sprayer fitted with flat-fan nozzle. Data on weed count and weed biomass from an area enclosed in a quadrate of 0.25 m^2 at two placesunder different herbicides treatments were recorded at 60days after sowing (DAS). Data on individual and total weed density and weed dry weight were subjected to square root transformation $\{\sqrt{x+1}\}$.

RESULTS AND DISCUSSION

Density and dry weight of weeds

The major weed flora in field comprised of *Phalaris minor* (25.0%), *Rumex maritimus* (8.9 %), *Coronopus dydimus* (53.2%), *Lathyrus aphaca* (5.7%) and *Medicago denticulata* (7.1%). Besides, small numbers of *Poaannua, Sprergula arvensis*, and *Viciahirsuta* were also observed in the experimental field. In both the years' density of broadleaf weeds out numbered the grassy weeds.

Sole application of *clodinafop* (60 g/ha) effectively controlled the grassy weed *Phalaris minor* but failed to provide effective control of broadleaf weeds viz. *Rumex maritimus, Coronopus dydimus, Lathyrus aphaca* and *Medicago denticulata* whereas metsulfuron (4g/ha) remained effective against all the broadleaf weeds but was ineffective against *Phalaris minor.* This may be due to their differential selectivity towards grassy and broadleaf weeds. The results are in agreement with (Bharat and Kachroo 2010 and Chopra and Chopra 2010).

Among the applied herbicides premix of Clodinafop + metsulfuron at 45+3, 54+3.5 and 60+4 and 180+12 g/ha recorded significant higher reduction of *Phalaris minor* compared to weedy check and metsulfuron at 4g/ha. Broadleaf weeds *Rumex maritimus, Coronopus dydimus, Lathyrus aphaca and Medicago denticulata* were significantly reduced with premix formulation of clodinafop + metsulfuron at 45+2, 54+3, 60+4 and 180+4g/ha compared to weedy check and clodinafop 60g/ha. Premix formulation of clodinafop + metsulfuron at all the doses recorded significantly lower total weed density of grassy as well as broadleaf weeds compared to weedy check, clodinafop 60g/ha and metsulfuron 4g/ha due to effective control of mixed weed flora (Table 1 and 2) owing to their synergetic interactions and compatibility (Bharat and Kachroo 2010 and Punia *et al.,* 2004).

Weed dry weight was significantly reduced in both the years under all the herbicidal treatments compared to weedy check. Clodinafop + metsulfuron at 45+3g/ha, 54+3.6 g/ha, 60+4 g/ha and 180+12 g/ha recorded significantly lower weed dry weight and higher weed control efficiency than clodinafop 60 g/ha and metsulfuron methyl 4g/ha owing to effective control of complex weed flora (Table 2). Higher weed dry weight and lower weed control efficiency in metsulfuron 4 g/ha compared to clodinafop 60g/ha in both the years indicate that *Phalaris minor* a grass weed which was not effectively controlled by metsulfuron was contributing more towards weed dry weight though weed density of broadleaf weeds was higher in clodinafop 60 g/ha in both the years (Table 2).

Yield attributes and yield

All the herbicide treatments and weed free check observed higher values of yield attributes *viz.*, grain weight/spike and number of spikes /m^2 compared to weedy check. Among the herbicides clodinafop + metsulfuron at 60 + 4 g/ha and weed free check registered 10.9 and 19.0% increase in grain weight /spike and 28.5 and 22.9% increase in number of spikes/m^2 compared to weedy check (pooled basis). Weed free conditions increased the availability on nutrients, space and light to the wheat crop due to absence of crop weed competition which resulted in increased

Table 1. Effect of different herbicides and their mixtures on weed density (0.5m^2) at 60 DAS in wheat

Treatment	*Phalaris minor*		*Coronopus dydimus*		*Rumex maritimus*		*Medicago denticulata*		*Lathyrus aphaca*	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop 60 g/ha	(*0.5) 1.2	(0) 1.0	(78) 8.6	(97.5) 9.5	(17.7)4.2	(24.5) 4.6	(7.2) 2.8	(24) 4.8	(18.2) 4.0	(2.5) 2.4
Metsulfuron 4 g/ha	(51.5) 7.2	(38) 6.2	(10) 2.6	(0.0) 1.0	(0) 1.0	(0.0) 1.0	(1.5) 1.4	(0.0) 1.0	(0.7) 1.25	(2.5) 1.6
Clodinafop + metsulfuron 45+3 g/ha	(0) 1.00	(1) 1.36	(5.5) 2.1	(0.0) 1.0	(0) 1.0	(0.0)1.0	(1.0) 1.3	(0.0) 1.0	(1.46)1.5	(0.0) 1.0
Clodinafop + metsulfuron 54+3.6 g/ha	(0) 1.00	(0) 1.0	(0) 1.00	(0.0) 1.0	(1.0)	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.7)1.25	(0.0) 1.0
Clodinafop + metsulfuron 60+4 g/ha	(0) 1.00	(0) 1.0	(0)1.00	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1,0	(0.0) 1.0	(0.0) 1.0
Clodinafop + metsulfuron 180+12 g/ha	(0) 1.00	(0) 1.0	(0) 1.00	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0 1.0)
Weed free	(0) 1.00	(0) 1.0	(0) 1.00	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0	(0.0) 1.0
Weedy check	(75) 8.5	(45.2) 6.8	(67) 8.1	(188) 14	(12.2)3.6	(30.5) 5.5	(8.7) 3.1	(25.5) 5.0	(17) 3.97	(10.5) 3.3
SEm±	0.50	0.15	0.63	0.60	0.26	0.43	0.18	0.36	0.52	0.35
CD (P=0.05)	1.13	0.5	1.86	1.95	0.77	1.37	0.53	1.17	1.71	1.09

*Figures inside the parenthesis are the original values, figures outside denotes transformed values.

yield attributes. Among the herbicides metsulfuron 4g/ha and clodinafop 60g/ha observed 14.7 and 11.5% less number of spikes/m^2 compared to clodinafop + metsulfuron (60+4g/ha) due to their inability to control grassy and broadleaf weed respectively. Higher level of number of spikes in clodinafop + metsulfuron at 60+4 g/ha may be attributed to low weed competition and clean cultivation.

The complex weed flora comprised of grasses and broadleaf weeds showed reduction of 24.7% in seed yield in weedy check compared to weed free and clodinafop + metsulfuorn 60 + 4 g/ha. Clidinafop 60g/ha and Clodinafop + metsulfuron 45+3, 54+3.6 g/ha registered significantly higher seed yield than weedy check in both the years due to control of*Phalaris minor* and broadleaf weeds. In both the years metsulfuron alone at 4g/ha failed to increase the seed yield significantly over weedy check possibly due to its lower weed control efficiency (Table 2). Clodinafop + metsulfuron 60 + 4g /ha improved the seed yield by 10.0 and 20.8% over sole application of clodinafop 60 g/ha and metsulfuron 4g/ha due to control of both grasses and broadleaf weeds whereas both clodinafop and metsulfuron when applied sole have differential selectivity for grasses and broadleaf weeds respectively (Table 3). Seed yield among different doses of premix combination of clodinafop + metsulfuon remain statistically at par among themselves and weed free treatment. Better performance of these treatments in terms of yield could be owing to higher no of spikes/m^2 and seed weight per spike due to better control of complex weed flora tilting the crop weed competition in favour of the crop. The results are in agreement to Chopra *et al.* (2008.) and Singh *et al.* (2010). No phytotoxicity was noticed under premix formulations of different doses of clodinafop + metsulfuron.

Economics

All the herbicides alone or in premix formulations recorded higher monetary returns over weedy check. Among the weed control treatment clodinafop + metsulfuron (60g/ha + 4g/ha) gave the maximum net returns and benefit cost ratio (1.26 and 0.84) due to excellent control of complex weed flora without any adverse effect on crop growth (Table 4). The herbicide mixture of premix clodinafop + metsulfuron at 45+3 and 54+3.6g/ha recorded higher mon-

Table 2. Effect of different herbicides and their mixtures on weed parameters at 60 DAS in wheat

Treatment	Total weed density (0.5m^2)		Total weed dry weight (0.5 m^2)		Weed control efficiency (%)		Weed index (%)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop 60g/ha	(*121.7) 11.0	(148.5) 12.3	(13.0) 3.70	(31.1) 5.14	89.3	52.1	8.94	9.65
Metsulfuronl 4g/ha	(63.7) 8.02	(38.5) 6.4	(46.9) 6.85	(34.9)5.81	61.4	46.3	21.20	12.12
Clodinafop+ metsulfuron 45 + 3 g/ha	(8.0) 2.6	(0.0) 1.0	(4.30) 2.30	(1.3)1.49	96.4	98.0	5.05	6.93
Clodinafop+ metsulfuron 54 + 3.6 g/ha	(0.75) 1.2	(0.0) 1.0	(1.60) 1.61	(1.5)1.56	98.6	97.7	0.97	4.70
Clodinafop+ metsulfuron 60 + 4 g/ha	(0.0) 1.0	(0.0) 1.0	(0.18) 1.08	(1.1)1.46	99.8	98.3	-1.16	1.73
Clodinafop+ metsulfuron 180 + 12 g/ha	(0.0) 1.0	(0.0) 1.0	(0.0) 1.00	(0.9)1.36	100.0	100.0	3.50	1.73
Weed free	(0.0) 1.0	(0.0) 1.0	(0.0) 1.00	(0.0) 1.0	100.0	100.0	-	-
Weedy check	(179.5) 13.4	(299.7) 17.7	(121.6) 11.0	(65) 8.06	-	-	27.62	20.29
SEm±	0.48	0.62	0.24	0.45	-	-	-	-
CD (P=0.05)	1.43	1.82	0.70	1.34	-	-	-	-

*Figures inside the parenthesis are the original values, figures outside denotes transformed values.

Table 3. Effect of different herbicides and their mixtures on yield attributes and seed yield in wheat

Treatment	Plant height (cm)		Seed weight/ spike (g)		Spikes/m^2		Grain yield t/ha		Biological yield (t/ha)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop 60 g/ha	80.1	88.1	1.81	1.44	281	285	4.68	3.65	7.9	7.2
Metsulfuron 4 g/ha	81.2	86.3	1.69	1.39	270	277	4.05	3.55	9.5	8.1
Clodinafop+ metsulfuron 45 + 3 g/ha	79.3	87.7	1.78	1.55	291	300	4.88	3.76	8.4	7.8
Clodinafop+ metsulfuron 54 + 3.6 g/ha	78.9	87.4	1.87	1.59	298	313	5.09	3.85	10.4	8.3
Clodinafop+ metsulfuron60 + 4 g/ha	81.6	86.5	1.73	1.54	320	320	5.20	3.97	10.7	8.6
Clodinafop + metsulfuron180 + 12 g/ha	80.7	87.5	1.77	1.59	320	310	4.96	3.97	11.2	8.9
Weed free	81.2	87.7	1.91	1.60	295	318	5.14	4.04	10.3	8.9
Weedy check	77.2	82.7	1.65	1.30	232	267	3.72	3.22	11.0	8.9
SEm±	0.72	0.70	0.05	0.05	17.3	5.81	0.23	0.11		
CD (P=0.05)	2.10	2.02	0.13	0.16	50.3	17.0	0.68	0.35	1.26	0.95

Table 4. Effect of different weed control treatments on economics of wheat

Treatment	Cost of cultivation (×10³ ₹/ha)		Net returns (×10³ ₹/ha)		Benefit: Cost ratio	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop 60 g/ha	19.3	21.3	20.5	16.0	1.06	0.75
Metsulfuron 4 g/ha	17.9	20.0	16.5	15.5	0.92	0.77
Clodinafop + metsulfuron 45 + 3 g/ha	18.9	20.9	22.6	16.7	1.19	0.79
Clodinafop + metsulfuron 54 + 3.6 g/ha	19.2	21.2	23.4	17.3	1.22	0.81
Clodinafop + metsulfuron 60 + 4 g/ha	19.6	21.6	24.7	18.3	1.26	0.84
Clodinafop + metsulfuron 180 + 12 g/ha	23.4	25.5	18.4	14.2	0.78	0.55
Weed free	22.6	24.7	21.0	15.7	0.93	0.63

etary advantage compared with sole application metsulfuron (4g/ha) and clodinafop (60g/ha). Weed free treatment registered lower monetary returns due to high cost involved in repeated weedings to keep crop weed free despite having higher grain yield (Table 4).

It was concluded that premix clodinafop+metsulfuron (60+4 g/ha) was the most remunerative and effective herbicide mixture for controlling the complex weed flora in wheat.

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