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Ready-mix formulation of clodinafop-propargyl + metsulfuron-methyl against complex weed flora in wheat

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ABSTRACT

Bio-efficacy of ready-mix formulation of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP was studied against complex weed flora in wheat during 2006-07 and 2007-08 at Hisar, India. Among different herbicidal treatments, clodinafop 0.06 kg/ha was found very effective (95-98%) only against grassy weeds. Metsulfuron 0.004 kg/ha was effective (88-90%) only against broad-leaf weeds. Sequential application of clodinafop 0.06 kg *fb* metsulfuron 0.004 kg/ha being statistically at par with clodinafop-propargyl + metsulfuron- methyl at 0.06 + 0.004 kg/ha and above proved very effective against complex weed flora and the control of grassy and broad-leaved weeds to the extent of 95%. clodinafop- propargyl + metsulfuron- methyl being at par with clodinafop *fb* metsulfuron 0.06 and 0.004 kg/ha recorded the number of spikes, 1000-grain weight and grain yield of wheat statistically similar to that of weed free check. There was no additional gain in grain yield of wheat by using higher doses of clodinafop- propargyl + metsulfuron- methyl beyond 0.06 + 0.004 kg/ha. Weeds allowed growing throughout the crop seasons resulted into 42.9 and 45.1% reduction in the grain yield of wheat during 2006-07 and 2007-08, respectively. There was no residual impact of clodinafop-propargyl + metsulfuron-methyl at x dose (0.06+ 0.004 kg/ha) and 2x dose (0.12 + 0.008 kg/ha) on succeeding crops of sorghum and moongbean. HPLC analysis indicated that there were no residues of clodinafop-propargyl + metsulfuron-methyl (x and 2x doses) at wheat harvest in soil, grains and straw. There was also no adverse effect of herbicides on physico-chemical properties of soil.

Key words: Complex weed flora, Persistence, Premix formulation, Ready mix formulation, Wheat, Weed control efficiency

Phalaris minor and *Avena ludoviciana* are two predominating grassy weeds which frequently infest wheat crop in different regions of India.Up to 1990s, *Phalaris minor* was effectively controlled by isoproturon but due to continuous use of this herbicide for 10-15 years coupled with rice-wheat monocropping, resistance in *P. minor* evolved against this herbicide in 1992-93 (Malik and Singh 1995). Consequently three alternate herbicides, clodinafop, fenoxaprop and sulfosulfuron were recommended for control of isoproturon-resistant *P. minor* in rice-wheat growing areas. These herbicides performed very well against isoproturon- resistant *P. minor* and restored wheat yields in north-west India particularly in Haryana and Punjab (Malik and Yadav 1997, Chhokar and Malik 2002, Chhokar *et al*. 2006). However, due to effective control of this single predominating weed, a shift in weed flora in favour of broad-leaved weeds was observed from last 4-5 years in this cropping system. *Rumex retroflexus*, *Malwa parviflora* and *Convolvulus arvensis* along with many other broad-leaved weeds frequently started infesting wheat fields in rice-wheat cropping system. To overcome the problem of broad-leaved weeds, three herbicide, *viz.* 2,4-D, metsulfuron and carfentrazone were recommended in Haryana and they are still performing quite well.

The problem of complex weed flora in wheat was successfully solved through sequential application of clodinafop, fenoxaprop or sulfosulfuron at 30-35 DAS *fb* 2,4-D, metsulfuron or carfentrazone. But it required two separate operations for aforesaid herbicide applications particularly in case of 2,4-D and metsulfuron which cause antagonistic effect on the efficacy of clodinafop and fenoxaprop (Yadav *et al*. 2002) and thus, adds to cost. Another herbicide as premix formulation of sulfosulfuron + metsulfuron was recommended against complex weed flora and it did very well but residual toxicity of this herbicide on sensitive succeeding crops (sorghum and maize) in rotation put a question mark on its wide acceptability. Likewise, mesosulfuron + iodosulfuron recommended against complex weed flora was reported to cause phytotoxicity not only to wheat crop but also to succeeding sorghum crop. Keeping these points in view, performance

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of clodinafop-propargyl 15% + metsulfuron-methyl 1%, WP, was studied in order to have another suitable alternative against complex weed flora in wheat under different cropping sequences.

MATERIALS AND METHODS

To evaluate the bio-efficacy of premix formulation of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (clodinafop- propargyl + metsulfuron- methyl), a field experiment was conducted during *Rabi* seasons of 2007-07 and 2007-08 at Research Farm of Department of Agronomy, CCS Haryana Agricultural University, Hisar, India. The experimental field was sandy loam in texture, low in available N (127.5 kg/ha), medium in available (18.0 kg/ha) and high in (498.7 kg/ha) with slightly alkaline in reaction (pH 8.2). The wheat variety *'PBW 343'* was sown on 29 November during 2006-07 and 30 November during 2007-08 using a seed rate of 85 kg/ha under furrow irrigated raised-bed system (FIRBS) by keeping two rows/ bed on the top of beds. The crop was raised with all recommended package of practices excepting herbicidal treatments. The experiment consisting of 10 treatments, *viz.* clodinafop 0.06 kg, metsulfuron 0.004 kg, clodinafop-propargyl + metsulfuron- methyl 0.045 + 0.003 kg, 0.054 + 0.0036 kg, 0.06 + 0.004 kg, 0.12 + 0.008 kg and 0.18 + 0.012 kg, clodinafop *fb* metsulfuron 0.06 and 0.004 kg/ha (sequential application) along with weedy and weed free check was laid out in randomized block design with four replications. The plot size was 6.0 x 2.1 m. The spray of herbicides was done at 42-45 (days after sowing) DAS with knapsack sprayer fitted with flat fan nozzle using 500 L of spray volume per ha.

The data on the density of individual weeds was recorded at 60 days after sowing and data on the dry weight of grassy and broad-leaved weeds was recorded at 60 and 120 DAS by placing three quadrates (0.5 x 0.5 m) per plot. Visual phytotoxicity on wheat crop was recorded at 15 and 30 days after treatment (DAT) using 0-100 scale (where 0 = no mortality and 100 = complete mortality). Since there was no crop phytotoxicity either at 15 or 30 DAT, the data recorded on this aspect has not been included herein. Residual effect of clodinafop- propargyl + metsulfuron-methyl at x dose (0.06+0.004 kg/ha) and 2 x dose (0.12 + 0.008 kg/ha) in comparison to untreated check was also evaluated on succeeding crops of sorghum and moongbean grown in sequence of wheat. Residual analysis of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP applied in wheat at 0.06 +0.004 kg/ha and 0.12 + 0.008 kg/ha compared to untreated check was also undertaken in soil, wheat grains and straw at harvest by using HPLC. The data on yield and yield attributes were recorded to draw inference of results.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field during 2006-07 was infested with *Phalaris minor*, *Avena ludoviciana*, *Melilotus alba*, *Chenopodium album*, *Rumex retroflexus*, *Coronopus didymus*, *Anagallis arvensis* and *Convolvulus arvensis* to the extent of 11.4, 57.1, 8.6, 5.7, 2.9, 5.7, 5.7 and 2.9%, respectively (Table 1). Whereas, the corresponding figures during 2007-08 were 9.4, 52.3, 7.0, 9.4, 7.4, 7.0, 5.5 and 4.7%, respectively (Table 2). Among different herbicidal treatments, clodinafop 0.06 kg/ha was found very effective (95-98%) only against grassy weeds (Table 3 and 4). Metsulfuron 0.004 kg/ha was effective (88-90%) only against broad-leaved weeds. Sequential application of clodinafop 0.06 kg *fb* metsulfuron 0.004 kg/ha being

Table 1. Weed density (no./m^2) at 60 DAS as affected by different treatments during 2006-07

Treatment	Dose (kg/ha)	*Phalaris minor*	*Avena ludoviciana*	*Melilotus alba*	*Chenopodium album*	*Rumex retroflexus*	*Coronopus didymus*	*Anagallis arvensis*	*Convolvulus arvensis*
Clodinafop	0.06	1.37(1)	1.65(2)	4.10(16)	3.00(8)	2.60(6)	3.30(10)	3.15(9)	2.60(6)
Metsulfuron	0.004	4.57(20)	9.20(84)	1.37(1)	1.35(1)	1.00(0)	1.00(0)	1.00(0)	1.95(3)
CP + MM	0.045+0.003	1.65(2)	2.40(5)	1.65(2)	1.65(2)	1.35(1)	1.35(1)	1.37(1)	1.95(3)
CP + MM	0.054+0.0036	1.65(2)	2.40(5)	1.65(2)	1.37(1)	1.37(1)	1.37(1)	1.35(1)	1.97(3)
CP + MM	0.06+0.004	1.37(1)	1.65(2)	1.37(1)	1.37(1)	1.00(0)	1.00(0)	1.00(0)	1.65(2)
CP + MM	0.12+0.008	1.00(0)	1.35(1)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.65(2)
CP + MM	0.18+0.012	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.65(2)
Clodinafop *fb* metsulfuron	0.06/0.004	1.35(1)	1.65(2)	1.35(1)	1.35(1)	1.37(1)	1.00(0)	1.00(0)	1.95(3)
Weed free	-	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)
Weedy check	-	4.10(16)	8.97(80)	3.60(12)	3.03(8)	2.17(4)	3.00(8)	3.00(8)	2.20(4)
LSD (P=0.05)		0.72	0.46	0.44	0.43	0.36	0.26	0.28	0.50

Figures in parentheses are original values and were transformed to $\sqrt{(x+1)}$ before statistical analyses, CP + MM - Clodinafop-propargyl + metsulfuron-methyl.

statistically at par with clodinafop-propargyl + metsulfuron-methyl 0.06 + 0.004 kg/ha and above proved very effective against complex weed flora and the control of grassy and broad-leaved weeds was to the extent of 95%. The density and dry weight of grassy as well as broad-leaved weeds were reduced with corresponding increase in the dose of clodinafop-propargyl + metsulfuron-methyl-406. However, clodinafop-propargyl + metsulfuron-methyl 0.06 + 0.004 kg/ha and its higher doses were equally effective against mixed weed flora compared to sequential application of clodinafop 0.06 kg *fb* metsulfuron 0.004 kg/ha.

Effect on crop

The impact of different weed control treatments was clearly reflected in terms of yield and yield parameters of wheat (Table 3 and 4). Among different herbicidal treatment, clodinafop-propargyl + metsulfuron-methyl-406 0.06 + 0.004 kg/ha and clodinafop *fb* metsulfuron 0.06 and 0.004 kg/ha recorded the number of spikes, 1000-grain weight and grain yield of wheat statistically similar to that of weed free check. There was no additional gain in grain yield of wheat by using higher doses of clodinafop-propargyl + metsulfuron-methyl beyond 0.06 + 0.004 kg/ha. The reason for lower yields in case of clodinafop and metsulfuron alone could obviously be due to almost no control of broad-leaved and grassy weeds, respectively.

Residual effects

There was no residual impact of clodinafop-propargyl + metsulfuron-methyl at x dose (0.06+ 0.004 kg/ha) and 2 x dose (0.12 + 0.008 kg/ha) on sorghum and moong bean (Table 5 and 6). HPLC studies also indicated that there

Table 2. Weed density (no./m^2) at 60 DAS as affected by different treatments during 2007-08

Treatment	Dose (kg/ha)	*Phalaris minor*	*Avena ludoviciana*	*Melilotus alba*	*Chenopodium album*	*Rumex retroflexus*	*Coronopus didymus*	*Anagallis arvensis*	*Convolvulus arvensis*
Clodinafop	0.06	1.70(2)	1.67(2)	3.45(11)	3.87(14)	2.80(7)	3.00(8)	2.80(7)	2.40(5)
Metsulfuron	0.004	3.85(14)	8.60(73)	1.37(1)	1.67(2)	1.37(1)	1.00(0)	1.00(0)	2.40(5)
CP + MM	0.045+0.003	1.70(2)	2.40(5)	1.67(2)	1.97(3)	1.70(2)	1.35(1)	1.37(1)	2.40(5)
CP + MM	0.054+0.0036	1.37(1)	1.97(3)	1.70(2)	1.67(2)	1.37(1)	1.37(1)	1.00(0)	2.60(6)
CP + MM	0.06+0.004	1.37(1)	1.97(3)	1.35(1)	1.70(2)	1.35(1)	1.00(0)	1.00(0)	1.97(3)
CP + MM	0.12+0.008	1.00(0)	1.37(1)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.97(3)
CP + MM	0.18+0.012	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.97(3)
Clodinafop *fb* metsulfuron	0.06/0.004	1.35(1)	1.70(2)	1.70(2)	1.70(2)	1.37(1)	1.00(0)	1.00(0)	1.67(2)
Weed free	-	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)
Weedy check	-	3.60(12)	8.25(67)	3.15(9)	3.62(12)	2.60(6)	3.17(9)	2.80(7)	4.02(6)
LSD (P=0.05)		0.33	0.39	0.42	0.37	0.35	0.27	0.19	1.41

Figures in parentheses are original values and were transformed to $\sqrt{(x+1)}$ before statistical analyses, CP + MM - Clodinafop-propargyl + metsulfuron-methyl.

Table 3. Effect of different treatments on dry weight of weeds, yield and yield attributing characters of wheat during 2006-07

Treatment	Dose (kg/ha)	Dry weight of weeds (g/m^2)				WCE (%) 120 DAS		Spikes (no./m^2)	1000-grain weight (g)	Grain yield (t/ha)
		60 DAS		120 DAS						
		Grassy weeds	Broad-leaved	Grassy weeds	Broad-leaved	Grassy weeds	Broad-leaved			
Clodinafop	0.06	6.4	39.1	5.2	59.6	98	3	397	36.6	4.31
Metsulfuron	0.004	129.6	3.4	252.4	6.2	2	90	325	34.9	3.19
CP + MM	0.045+0.003	12.8	6.1	18.1	9.9	93	84	414	38.1	4.58
CP + MM	0.054+0.0036	10.9	5.0	18.0	7.4	93	88	426	39.7	4.78
CP + MM	0.06+0.004	5.8	3.9	2.6	3.7	99	94	452	41.3	4.98
CP + MM	0.12+0.008	2.5	1.7	0.0	0.0	100	100	457	41.8	5.05
CP + MM	0.18+0.012	0.0	1.5	0.0	0.0	100	100	456	41.9	5.05
Clodinafop *fb* metsulfuron	0.06/0.004	5.3	3.8	2.6	3.1	99	95	452	41.5	4.99
Weed free	-	0.0	0.0	0.0	0.0	100	100	458	41.9	5.05
Weedy check	-	128.5	30.7	259.0	61.8	0	0	315	33.1	2.88
LSD (P=0.05)		3.3	1.6	7.0	2.4	-	-	10	0.9	0.12

Figures in parentheses are original values and were transformed to $\sqrt{(x+1)}$ before statistical analyses, CP + MM - Clodinafop-propargyl + metsulfuron-methyl.

Table 4. Effect of different treatments on dry weight of weeds, yield and yield attributing characters of wheat during 2007-08

Treatment	Dose (kg/ha)	Dry weight of weeds (g/m^2)				WCE (%) at 120 DAS		Spikes (no./m^2)	1000-grain weight (g)	Grain yield (t/ ha)
		60 DAS		120 DAS						
		Grassy weeds	Broad-leaved	Grassy weeds	Broad-leaved	Grassy weeds	Broad-leaved			
Clodinafop	0.06	7.7	41.0	9.6	76.9	95.5	4.3	386	35.8	4.19
Metsulfuron	0.004	100.4	5.2	202.9	10.0	5.0	87.6	319	34.2	3.31
CP + MM	0.045+0.003	22.4	8.4	41.9	16.1	80.4	80.0	410	37.7	4.48
CP + MM	0.054+0.0036	15.4	7.1	28.2	12.4	86.8	84.6	423	39.4	4.61
CP + MM	0.06+0.004	7.2	5.4	4.9	5.6	97.7	93.0	455	41.6	4.83
CP + MM	0.12+0.008	3.2	2.4	2.3	1.4	98.9	98.2	457	41.8	4.88
CP + MM	0.18+0.012	0.1	2.2	0.0	0.2	100.0	99.7	454	41.7	4.88
Clodinafop *fb* metsulfuron	0.06/0.004	6.8	5.3	4.5	4.5	97.9	94.4	454	41.6	4.84
Weed free	-	0.0	0.0	0.0	0.0	100.0	100.0	457	41.8	4.89
Weedy check	-	103.7	38.3	213.6	80.4	0.0	0.0	312	32.9	2.68
LSD (P=0.05)		3.8	2.0	6.8	1.9	-	-	3	1.2	0.06

Figures in parentheses are original values and transformed to $\sqrt{(x+1)}$ before statistical analysis; CP + MM - Clodinafop-propargyl + metsulfuron-methyl.

Table 5. Residual effect of different herbicides applied in wheat on yield of succeeding crop of sorghum

Treatment	Dose (kg/ha)	Plant height at 45 DAS (cm)		No. of plants/m.r.l at 45 DAS		Green fodder yield at 60 DAS (t/ha)	
		2007	2008	2007	2008	2007	2008
CP + MM	0.06 + 0.004	132.6	134.3	14.7	14.5	0.359	0.375
CP + MM	0.12 + 0.008	134.0	132.8	13.8	13.8	0.357	0.374
Untreated check	-	132.4	134.2	13.6	14.2	0.360	0.376
LSD (P=0.05)	-	NS	NS	NS	NS	NS	NS

Table 6. Residual effect of different herbicides applied in wheat on yield of succeeding crop of moong bean

Treatment	Dose (kg/ha)	Plant height at 45 DAS (cm)		No. of plants /m.r.l at 45 DAS		Green fodder yield at 60 DAS (t/ha)	
		2007	2008	2007	2008	2007	2008
CP + MM	0.06 + 0.004	71.9	71.9	14.7	13.9	0.886	0.888
CP + MM	0.12 + 0.008	71.5	71.7	14.6	13.8	0.868	0.885
Untreated check	-	72.0	72.3	14.7	14.2	0.867	0.909
LSD (P=0.05)	-	NS	NS	NS	NS	NS	NS

were no residues of clodinafop-propargyl + metsulfuron-methyl (x and 2 x doses) at wheat harvest in soil, grains and straw. Persistence studies clearly indicated that this herbicide can safely be used in wheat under different crop rotations without any cause of concern.

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