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Metribuzin + clodinafop-propargyl effects on complex weed flora in wheat and its residual effect on succeeding crop

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ABSTRACT

A field experiment was carried out at Norman E. Borlaug Crop Research Centre of G.B.P.U.A&T, Pantnagar during *Rabi* seasons of 2010-11 and 2011-12 to test the efficacy of different dosses of metribuzin 42% + clodinafop propargyl 12% WG against weeds in wheat. The soil of the experimental field was clay loam in texture, medium in organic carbon (0.67%), available phosphorus (29.6 kg/ha) and potassium (176.4 kg/ha) with pH 7.2. Results revealed that metribuzin + clodinafop-propargyl at 500-600 g/ha were as effective as two hand weeding at 30 and 50 DAS in reducing the weed density of *Phalaris minor* and *Chenopodium album, Cornopus didymus, Melilotus* spp., *Rumex* spp. and *Fumaria parviflora* at 30 and 60 days after application as compared to rest treatments. Maximum grain yield was recorded in metribuzin + clodinafop-propargyl WG at 600 g/ha which was statistically at par with its lower dose of 500 g/ha due to effective control of grassy and broad-leaved weeds in wheat.

Key words: Clodinafop-propargyl, Efficacy, Metribuzin, Residual effect, Wheat

Wheat (*Triticum aestivium*) is heavily infested with *Phalaris minor*, *Avena ludoviciana*, *Chenopodium album*, *Medicago denticulata*, *Melilotus alba*, *Melilotus indica*, *Fumaria parviflora*, *Vicia hirsuta*, *Vicia sativa*, *Coronopus didymus* and *Rumex acetocella.* Uncontrolled weeds are reported to cause upto 66% reduction in wheat grain yield (Angiras *et al.* 2008, Kumar *et al.* 2009 and Kumar *et al.* 2011) or even more depending upon the weed density, type of weed flora and duration of infestation. Chemical weed control is a preferred practice due to scarce and costly labour as well as lesser feasibility of mechanical or manual weeding especially in broadcast wheat. Combination of isoproturon and 2,4-D as tank mixture has been recommended against complex weed flora. This combination has been found promising in the situation where isoproturon was effective against *Phalaris minor*. However against complex weed flora dominated by *Avena ludoviciana*, *Lolium temulentum* and *Poa annua*, combination of isoproturon and 2,4-D was not so effective.Under such situation, a suitable combination of clodinafop and pinoxaden with some broad-spectrum herbicides like metribuzin is needed. Hence, the present investigation was carried out to evaluate the efficacy of metribuzin in combination with recommended clodinafop against mixed weed flora in wheat.

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MATERIALS AND METHODS

A field trial was carried out during *Rabi* of 2010-11 and 2011-12 at Pantnagar to evaluate the bio-efficacy of metribuzin 42% + clodinafop propargyl. The soil of the experimental field was clay loam in texture, medium in organic carbon (0.67%), available phosphorus (29.6 kg/ha) and potassium (176.4 kg/ha) with pH 7.2**.** Ten treatments were evaluated in randomized block design with three replication. The treatments comprised of three doses of metribuzin + clodinafop-propargyl WG at 400, 500 and 600 g/ha as test product and isoproturon 75% WP at 1333.3 g/ha, metribuzin 70% WP at 300 g/ha, sulfosulfuron 75% at 33.3 g/ha, clodinafop-propargyl at 400 g/ha, mesosulfuron-methyl 3% + idosulfuron-methyl sodium 0.6% WG at 400 g/ha weeding at 30 and 50 days after sowing (DAS) and untreated control. The wheat variety '*UP- 2565*' was sown on November 23, 2010 and November 18, 2011, respectively. Recommended package of practices were followed to raise the wheat. The data on density and dry weight of total weeds were taken at 30 and 60 DAS and grain yield (kg/ha) was recorded at the time of harvesting.

In addition of bio-efficacy, a separate experiment was also carried out to observe the phytotoxicity effect of metribuzin 42% + clodinafop propargyl 12% WG on wheat crop, *viz.* yellowing, necrosis, epinasty, hyponasty and scorching and to see the residual effect on succeeding crops 'maize'.

Metribuzin + clodinafop-propargyl at 500 and 1000 g/ha were applied at 35 days after sowing of wheat crop using prescribed volume of water and surfactant. Phytotoxicity symptoms, *viz.* yellowing, necrosis, epinasty, hyponasty and scorching were recorded at 7, 15 and 30 days after treatment using rating scale of 0-10 where, where, 0= no effect on plant and 10= complete death of the plant.

Maize crop was planted by dibbling method after one week of harvesting of wheat crop in the plots which was treated with metribuzin + clodinafop propargyl at 500 and 1000 g/ha in wheat to see the residual effect on germination and growth of maize crop. Untreated check was also maintained for comparison. The maize crop was raised as per the standard agronomical practices of the university.

RESULTS AND DISCUSSION

Effect on weeds

Experimental field was naturally dominated with *Phalaris minor* (5.74 and 40.7%) as a grassy weed and C*henopodium album* (2.8 and 13.3%), *Cornopus didymus* (2.8 and 10.4%), *Melilotus indica*, (2.5 and 9.4%) *Rumex* spp., (2.0 and 4.8%) and *Fumeria parviflora* (1.8 and 3.8%), were major broad-leaf weeds infesting experimental area during 2010 and 2011, respectively.

Efficacy against grassy weeds

Metribuzin + clodinafop-propargyl at 500 g/ha and metribuzin + clodinafop-propargyl at 600 g/ha were significantly at par with two hand weeding at 30 and 50 days after sowing of wheat which recorded the lowest weed density at 30 and 60 days after application as compared to rest of the treatments. Application of sulfosulfuron 75% at 33.3 g/ha and mesosulfuron-methyl + idosulfuron-methyl sodium at 400g/ha were however significantly superior over untreated control plot but found to be least effective against *P. minor* as compared to rest of the herbicidal treatments when observed at 30 and 60 days after treatment. Efficacy of clodinafop propargyl 15% WP at 400 g/ha against *P. minor* were at par to metribuzin 42% + clodinafop propargyl 12% WG at 400 g/ha (Table 1 and 2).

Efficacy against broad-leaf weeds

The data on efficacy of the herbicides on the density of broad-leaf weeds recorded at 30 and 60 days after treatment, respectively (Table 1 and 2), Metribuzin + clodinafop-propargyl at 600 g/ha at 500 g/ha was at par with its higher dose *i.e.* at 600 g/ha and mesosulfuron-methyl + idosulfuron-methyl sodium at 400 g/ha, metribuzin at 300 g/ha and two hand weeding at 30 and 50 days after sowing against broad-leaf weeds, *viz.* C. *album*, *C. didymus*,

Table 1. Effect of metribuzin + clodinafop-propargyl and other herbicides on density of weeds at 30DAS during 2010 and 2011.

Treatment	Product dose (g/ha)	Surfactant volume (ml/ha)	Weed density*/m^2 at 30 DAS											
			P. minor		*C. didymus*		*C. album*		Rumex spp.		*M. indica*		*F. parviflora*	
			2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Metribuzin + clodinafop-propargyl	400	1250	19.3 (4.5)	4.28 (17.3)	5.3 (2.5)	2.54 (6.7)	4.0 (2.2)	2.49 (5.3)	4.0 (2.2)	2.49 (5.3)	2.3 (1.8)	2.08 (4.0)	3.0 (2.0)	1.83 (2.7)
Metribuzin + clodinafop-propargyl	500	1250	7.7 (2.9)	2.75 (6.7)	0.3 (1.1)	1 (0.0)	0.0 (1.0)	1 (0.0)	1.0 (1.4)	1.42 (1.3)	0.0 (1.0)	1.42 (1.3)	0.0 (1.0)	1.0 (0.0)
Metribuzin + clodinafop-propargyl	600	1250	2.3 (1.8)	1.83 (2.7)	15.7 (4.1)	4.43 (18.7)	14.3 (3.9)	5.97 (34.7)	5.3 (2.5)	3.40 (10.7)	11.3 (3.5)	3.60 (12.0)	7.0 (2.8)	3.20 (9.3)
Isoproturon	1333.3	-	32.0 (5.7)	5.29 (27)	1.0 (1.4)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.42 (1.3)	1.0 (1.4)	1.0 (0.0)
Metribuzin	300	-	33.0 (5.8)	5.13 (25.3)	4.7 (2.4)	2.08 (4.0)	3.7 (2.2)	1.83 (2.7)	3.7 (2.2)	2.49 (5.3)	1.7 (1.6)	1.42 (1.3)	1.0 (1.4)	1.42 (1.3)
Clodinafop-propargyl	400	-	3.7 (2.2)	1.83 (2.7)	1.7 (1.6)	1.42 (1.3)	1.0 (1.4)	1.42 (1.3)	2.3 (1.8)	1.83 (2.7)	1.3 (1.5)	1.83 (2.7)	0.7 (1.3)	1.83 (2.7)
Mesosulfuron-methyl + idosulfuron-methyl sodium + surfactant	400	500	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	1.0 (1.4)	1.0 (0.0)	0.7 (1.3)	1.0 (0.0)	0.7 (1.3)	1.42 (1.3)
Sulfosulfuron + surfactant	33.3	1250	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	1.0 (1.4)	1.0 (0.0)
Hand weeding at 30 and 50 DAS	-	-	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)	1.0 (1.4)	1.0 (0.0)	0.0 (1.0)	1.0 (0.0)
Untreated control	-	-	72.0 (8.5)	8.15 (65.3)	13.7) (3.8	4.87 (22.7)	17.0 (4.2)	5.85 (33.3)	6.0 (2.6)	3.78 (13.3)	13.0 (3.7)	3.40 (10.7)	6.3 (2.7)	3.58 (12.0)
LSD (P=0.05)			0.46	0.69	0.41	1.06	0.23	0.70	0.53	0.73	0.43	1.01	0.47	0.84

* Figures in parentheses indicates original values

Table 2. Effect of metribuzin + clodinafop-propargyl and other herbicides on density of weeds at 60 DAS during 2010 and 2011

Treatment	Product dose (g/ha)	Surfactant volume (ml/ha)	Weed density*/m^2 at 60 DAS											
			P. minor		*C. didymus*		*C. album*		Rumex spp.		*M. indica*		*F. parviflora*	
			2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Metribuzin + clodinafop-propargyl	400	1250	17.0 (4.2)	3.95 (14.7)	7.0 (2.8)	2.49 (5.3)	3.0 (2.0)	2.08 (4.0)	3.3 (2.1)	2.08 (4.0)	5.0 (2.4)	2.08 (4.0)	2.0 (1.7)	1.83 (2.7)
Metribuzin + clodinafop-propargyl	500	1250	5.0 (2.4)	2.08 (4.0)	0.3 (1.1)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	1.7 (1.6)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)
Metribuzin + clodinafop-propargyl	600	1250	3.3 (2.1)	1.83 (2.7)	16.7 (4.2)	4.10 (16.0)	18.3 (4.4)	4.57 (20.0)	5.0 (2.4)	2.54 (6.7)	10.3 (3.4)	3.32 (10.7)	5.0 (2.4)	2.54 (6.7)
Isoproturon	1333.3	-	29.7 (5.5)	4.86 (22.7)	0.0 (1.0)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	1.0 (1.4)	1.00 (0.0)
Metribuzin	300	-	25.0 (5.1)	4.43 (18.7)	4.7 (2.4)	1.83 (2.7)	6.7 (2.8)	1.83 (2.7)	4.0 (2.2)	2.08 (4.0)	1.0 (1.4)	1.82 (2.7)	0.0 (1.0)	1.00 (0.0)
Clodinafop-propargyl	400	-	3.7 (2.2)	1.83 (2.7)	0.7 (1.3)	1.42 (1.3)	1.7 (1.6)	1.42 (1.3)	1.0 (1.4)	1.42 (1.3)	1.0 (1.4)	1.42 (1.3)	0.7 (1.3)	1.00 (0.0)
Mesosulfuron-methyl + idosulfuron-methyl sodium + surfactant	400	500	0.7 (1.3)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.7 (1.3)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.7 (1.3)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)
Sulfosulfuron + surfactant	33.3	1250	0.7 (1.3)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.3 (1.1)	1.00 (0.0)	1.0 (1.4)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)
Hand weeding at 30 and 50 DAS	-	-	2.0 (1.7)	1.83 (2.7)	0.3 (1.1)	1.42 (1.3)	1.0 (1.4)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)	0.7 (1.3)	1.00 (0.0)	0.0 (1.0)	1.00 (0.0)
Untreated control	-	-	65.3 (8.1)	7.64 (57.3)	15.0 (4.0)	3.87 (14.7)	14.0 (3.9)	4.43 (18.7)	6.7 (2.8)	2.54 (6.7)	11.0 (3.5)	3.73 (13.3)	6.0 (2.6)	2.49 (5.3)
LSD (P=0.05)			0.52	0.91	0.28	0.98	0.42	0.84	0.71	NS	0.51	0.89	0.40	0.89

Figures in parentheses indicates original values

Table 3. Effect of metribuzin + clodinafop-propargyl and other herbicides on dry weight of weeds at 30 and 60 DAS (mean of 2010 and 2011)

Treatment	Product dose (g/ha)	Surfactant (ml/ha)	Weed dry weight (g/m^2) 30 DAS			WCE (%)	Weed dry weight (g/m^2) 60 DAS			WCE (%)
			GW	BLW	Total		GW	BLW	Total	
Metribuzin + clodinafop-propargyl	400	1250	2.0	7.9	9.9	93.8	4.8	8.9	13.7	93.4
Metribuzin + clodinafop-propargyl	500	1250	0.0	1.3	1.3	99.2	0.0	0.0	0.0	100.0
Metribuzin + clodinafop-propargyl	600	1250	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
Isoproturon	1333.3	-	12.6	23.0	35.6	77.7	26.3	37.5	63.8	69.5
Metribuzin	300	-	5.2	3.1	8.3	94.8	6.7	1.7	8.4	96.0
Clodinafop-propargyl	400	-	1.7	52.3	54.0	66.1	4.5	93.5	98.0	53.1
Mesosulfuron-methyl + idosulfuron-methyl sodium + surfactant	400	500	23.8	2.3	26.1	83.4	40.8	3.3	44.1	78.9
Sulfosulfuron + surfactant	33.3	1250	21.3	13.5	34.8	78.2	29.9	20.9	50.8	75.7
Hand weeding at 30 and 50 DAS	-	-	0.0	0.0	0.0	100.0	4.0	3.4	7.4	96.5
Untreated control	-	-	74.1	85.4	159.5	0. 0	117.5	91.7	209.2	0.0
LSD (P=0.05)			11.8	5.8	13.1	-	35.2	5.3	35.0	-

GW= Grassy weeds, BLW= Broad-leaf weeds

Melilotus spp., *Rumex* spp., and *F. parviflora* with recorded lowest density of weeds at 30 and 60 days after treatment. Clodinafop-propargyl at 400 g/ha found to be ineffective against broad-leaf weeds. Excellent control of complex weed flora in wheat was observed with the tank mix application of clodinafop + metsulfuron (15:1 ratio) at 60 g/ha (Punia *et al*. 2004).

Weed dry matter production

Weed management treatments significantly reduced the population and dry matter of grassy as well as broad-leaved weeds as compared to weedy check (Table 3). At 30 and 60 DAS, significantly lowest dry weed weight of grassy was recorded with metribuzin + clodinafop-propargyl at 500 g/ha which was at par with its higher dose *i.e*. 600 g/ha and mesosulfuron-methyl + idosulfuron-methyl sodium at

Table 4. Effect of metribuzin + clodinafop propargyl and other herbicides on yield attributed characters and grain yield of wheat during 2010 and 2011

Treatment	Product dose (g/ha)	Surfactant (ml/ha)	Plant height (cm)		No. of spikes /m^2		1000 grain wt (g)		Grain yield (t/ha)	
			2010	2011	2010	2011	2010	2011	2010	2011
Metribuzin + clodinafop-propargyl	400	1250	100.6	100.4	258.7	255.0	46.0	44.7	5.61	5.56
Metribuzin + clodinafop-propargyl	500	1250	101.9	101.3	256.0	251.7	45.4	45.1	5.60	5.54
Metribuzin + clodinafop-propargyl	600	1250	101.9	100.9	268.0	259.3	45.1	44.9	5.64	5.59
Isoproturon	1333.3	-	100.5	100.7	257.0	235.3	44.7	43.2	5.35	5.41
Metribuzin	300	-	102.2	102.3	266.0	247.0	46.6	43.9	5.57	5.47
Clodinafop-propargyl	400	-	101.3	101.7	261.7	245.3	45.6	44.3	5.54	5.49
Mesosulfuron-methyl + idosulfuron-methyl sodium + surfactant	400	500	99.8	101.3	248.7	231.7	44.1	42.9	4.90	5.12
Sulfosulfuron + surfactant	33.3	1250	100.1	99.8	259.0	224.0	44.5	42.3	5.32	4.89
Hand weeding at 30 and 50 DAS	-	-	100.1	100.3	260.0	240.0	46.5	43.5	5.57	5.47
Untreated control	-	-	103.2	103.3	241.3	157.7	42.1	41.8	4.27	3.15
LSD (P=0.05)			NS	NS	14.4	29.4	2.3	1.3	0.06	0.09

400 g/ha, metribuzin at 300 g/ha and twice hand weeding at 30 and 50 days after sowing.Similiar trend was observed in case of dry matter accumulation in broad-leaved weeds at both the stages of observations *i.e.* at 30 and 60 DAS during 2010 and 2011.

Weed control efficiency

Among the herbicidal treatments, hundred per cent weed control efficiency of grassy and broad leaf weeds were recorded with application of metribuzin + clodinafop propargyl g/ha followed by its lower dose applied at 500 g/ha at 30 and 60 DAS, respectively. However lowest weed control efficiency was recorded with alone application of metribuzin at 300 g/ha at both the stages of observations *i.e.* at 30 and 60 DAS

Effect on crop

Unchecked weed growth reduced grain yield of wheat by 43% when compared with metribuzin + clodinafop-propargyl at 600 g/ha. Maximum yield (5.64 and 5.59 t/ha) was recorded from metribuzin + clodinafop-propargyl at 600 g/ha, which was followed by its lower dose at 500 g/ha (4.15 t/ha) and twice hand weeding at 30 and 50 DAS (5.60 and 5.54 kg/ha). Higher grain yield with metribuzin + clodinafop propargyl at 600 g/ha was due to more number of effective tillers and number of grains/ear.

Phytotoxicity

There was no phytotoxic effect of metribuzin + clodinafop-propargyl at 500 and 1000 g/ha on wheat crop.

Residual effect on succeeding crops

Residues of metribuzin + clodinafop-propargyl applied in wheat even at 500 and 1000 g/ha did not cause any adverse effect on crop growth and germination of succeeding maize crop.

On the basis of field study, it can be concluded that metribuzin + clodinafop-propargyl at 500 g/ha was found optimum dose in wheat for effective control of weeds and to attain higher grain yield of wheat without any phyto-toxicity to wheat or on maize, which were planted as succeeding crops after harvesting of wheat crop.

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