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Compatibility of herbicides against grassy weeds in wheat

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ABSTRACT

Field and pot studies were conducted to determine the compatibility of dicamba in tank mix combination with sulfosulfuron and clodinafop against weeds of wheat (*Triticum aestivum*). Dicamba alone was effective against broad-leaf weeds only. No significant difference for broad-leaf weed control was observed between dicamba doses of 240 and 360 g/ha. Dicamba in combination with clodinafop and sulfosulfuron controlled the broad spectrum weed flora. The efficacy of dicamba in combination with clodinafop and sulfosulfuron was not affected for broad-leaf weed control. However, *Phalaris minor* control with clodinafop was reduced when dicamba applied as tank mix combination. The efficacy of sulfosulfuron was not affected by dicamba when applied as tank mixture and as a result this mixture (sulfosulfuron + dicamba 25 + 120 g/ha) had the highest wheat grain yield (4.99 t/ha). *P. minor* dry weight reduction with clodinafop 60 g/ha alone and in tank mix combination with dicamba 240 g/ha was 97.3 and 58.3%, respectively. In pot studies also, the tank mixing of dicamba did not affect the sulfosulfuron efficacy but clodinafop efficacy was significantly reduced against *P. minor*. The *P. minor* biomass reduction with clodinafop 30 and 60 g/ha was 84.8 and 99.6%, respectively and when dicamba 240 g/ha was added, the fresh weight reduction reduced to 62.6 and 78.6%, respectively, compared to untreated control.

Key words: Antagonism, Broad-leaved weed, Herbicide mixture, *Phalaris minor*, wild oat

Weed infestation is one of the major constraints in achieving potential yield of wheat. The losses caused by weeds vary depending on the weed species, their abundance, crop management practices and environmental factors. Under extreme cases, losses can be complete crop failure (Malik and Singh 1993). The higher cost and less efficacy of manual weeding in wheat made chemical weed control popular. Generally, both grass and broad-leaf weeds infest wheat (Singh *et al.* 1995, Chhokar and Malik 2002). Among grassy weeds, littleseed canary grass (*Phalaris minor*) and wild oat (*Avenaludoviciana*) are major troublesome weeds under irrigated conditions in wheat crop (Singh *et al.* 1995). Broad-leaf weeds become a problem, where herbicides alone are used for combating the grass weed problem. Dicamba (3,6-dichloro-2-methoxybenzoic acid) an auxin type herbicide was found quite effective against broad-leaf weeds (Chhokar *et al.* 2007a).

Clodinafop and sulfosulfuron are two major herbicides being used by wheat grower in north western Indian plains (Chhokar and Malik 2002, Chhokar and Sharma 2008). Clodinafop controls grasses and not effective against broad-leaved weeds, whereas, sulfosulfuron controls several grasses and broad-leaved weeds. Sulfosulfuron is also not effective against some of the broad-leaved weeds like *Rumex* spp. and *Convolvulus arvensis* Linn. (Chhokar *et al.* 2007a). *Rumex dentatus* was highly competitive and drastically reduced wheat yield (Chhokar *et al.* 2007b). Dicamba, besides controlling *Rumex dentatus* and *Convolvulus arvensis*, also controlled many other broad-leaf weeds (Chhokar *et al.* 2007a). To control diverse weed flora, applications of two or more herbicides are needed. To save time and cost, instead of sequential application of herbicides, it is advantageous to tank mix broad-leaf weed herbicide with graminicide to control broad spectrum weed flora. However, the major requirement is that they should be compatible and the chances of herbicide compatibility in poaceae (grasses) is very less (20%) (Zhang *et al.* 1995). There are some reports of reduced efficacy of sulfonylurea and aryloxyphenoxy propionate herbicides when tank mixed with dicamba. However, the compatibility of dicamba with sulfosulfuron and clodinafop for *P. minor* control have not been evaluated. Keeping these in view, the present study was undertaken with the aim to determine the compatibility of dicamba with sulfosulfuron and clodinafop for control of weeds in wheat.

MATERIALS AND METHODS

Field study

Field studies were conducted for two consecutive *Rabi* seasons of 2006-07 and 2007-08 at Resource Man-

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agement Block, Directorate of Wheat Research, Karnal, Haryana, India. Wheat CV. *'PBW-343'* was sown on 20^{th} and 21^{st} November during 2006 and 2007, respectively at a row spacing of 20 cm using 100 kg seed/ha keeping three replications in randomized block design. The soil of the experimental field was sandy clay loam with pH of 8.0 and organic carbon content 0.39%. A recommended dose of fertilizer (150 kg N, 60 kg P, 40 kg K and 25 kg Zn/ha) was applied at sowing except nitrogen, which was applied in three splits, ($1/3^{rd}$ basal, $1/3^{rd}$ at first and $1/3^{rd}$ at second irrigation). The field was infested with weed flora dominated by *Phalaris minor*, *Avena ludoviciana, Melilotus indica. Medicago denticulata, Rumex dentatus, Anagallis arvensis* and *Coronopus didymus* (Table 1). First irrigation was applied at CRI stage *i.e* 21 days after sowing (DAS). The weed control treatments comprised of dicamba alone (240 and 360 g/ha) and in combination with clodinafop and sulfosulfuron along with untreated weedy control (Table 1). In combination, treatments consisted of dicamba + clodinafop at 120 + 60 and 240 + 60 g/ha and dicamba + sulfosulfuron at 120 +25 g/ha. Cationic surfactant was used 1250 ml/ha with sulfosulfuron. The herbicides were sprayed at 38-40 DAS with knapsack sprayer fitted with two flat fan nozzles boom using 350 l. water/ha. Dry weight of grass and broad-leaved weeds was recorded at 120 DAS by placing a quadrant (50 x 50 cm) at two places in each plot. The crop was manually harvested in the second week of April and net plot threshed using small plot thresher.

Pot study

Pot experiment was conducted to confirm the field study results on compatibility of clodinafop and sulfosulfuron with dicamba. About fifty seeds of *P. minor* were sown in pots (4.5 kg soil capacity having 20 cm top diameter) filled with soil : FYM in ratio of 6:1 (v/v). At 20 DAS, ten plants per pot were kept for herbicide evaluation. Herbicides, clodinafop (30 and 60 g/ha) and sulfosulfuron (12.5 and 25 g/ha) were applied without and with dicamba (240 g/ha). The cationic surfactant at 1000 ml/ha was used with sulfosulfuron treatments. At the time of herbicide spraying, *P. minor* was at 3-4 leaf stage and for spraying a solution of 350 l/ha was delivered using knapsack sprayer fitted with flat fan nozzles. Four week after herbicide spray, fresh weight of *P. minor* was recorded and based on fresh weight of control pots, the relative per cent fresh weight reduction under various treatments was calculated. Experiment was repeated with three replications in CRD and significance was compared using "paired t test" at P = 0.05 level.

RESULTS AND DISCUSSION

The major weed flora infested the experimental field comprised of grassy weeds (*P. minor* and *A. ludoviciana)* and among broad-leaf weeds, major were *Medicago denticulata*, *Melilotus alba*, *Rumex dentatus* and *Coronopus didymus.* Dicamba alone was effective against broad-leaved weeds only (Table 1). Dicamba at 240 and 360 g/ha provided good control of broad-leaved weeds and was significantly better compared to sulfosulfuron, clodinafop and weedy control. No significant difference for broad-leaf weed control was observed between dicamba doses of 240 and 360 g/ha. The tank mix application of dicamba with clodinafop and sulfosulfuron provided significant reduction in dry weight of grasses and broad-leaf weeds compared to untreated control. The ineffectiveness of dicamba against grass weeds resulted in poor wheat grain yield due to strong competition from grassy weeds. The yield recorded under dicamba in combination with clodinafop and sulfosulfuron application was significantly better as compared to weedy check and dicamba application alone due to control of complex weed flora. The presence of weeds throughout the crop season reduced the grain yield by 54.2% in comparison to tank mix application of sulfosulfuron + dicamba. The efficacy of sulfosulfuron was not affected by dicamba when applied as tank mixture (sulfosulfuron + dicamba 25 + 120 g/ha) resulting in the highest grain yield (4.99 t/ha). The total weed dry weight under this treatment was only 21.9 g/m^2. Dicamba efficacy against broad-leaf weeds was not affected by tank mix combination with clodinafop and sulfosulfuron.

Clodinafop 60 g/ha alone application reduced the *P. minor* dry weight by 97.3% and the tank mix application of clodinafop 60 g/ha with dicamba 240 g/ha reduced the *P. minor* dry weight by 58.3% compared to untreated control. The antagonistic effect of tank mix application of dicamba and clodinafop for *P. minor* control was also confirmed under pot studies (Fig. 1).The application of clodinafop at 30 and 60 g/ha reduced the fresh biomass of *P. minor* by 84.8 and 99.6%, respectively compared to weedy control. The addition of dicamba as tank mix combination with clodinafop resulted in significantly less reduction of *P. minor* biomass compared to sole clodinafop. The reduction in *P. minor* fresh biomass with clodinafop + dicamba at 30 + 240 and 60 + 240 g/ha was 62.6 and 78.6%, respectively. The reduction in efficacy of ACCase inhibitor herbicides on grasses with tank mixing of dicamba has been reported earlier (Dernoeden and Fidanza 1994, Olson and Nalewaja 1981). Dernoeden and Fidanza (1994)

Table 1. Effects of dicamba alone and in combination against weeds in wheat (pooled data of two years)

Herbicide	Dose g/ha	Weed dry weight (g/m²) *P. minor*	Wild Oat	Broad-leaved	Total grassy weeds	Total weeds	Wheat grain Yield (t/ha)
Dicamba	240	14.1(200)*	10.8(120)	1.03(0.1)	17.8(321)	17.9(321)	2.54
Dicamba	360	13.7(191)	11.5(133)	1.00(0.0)	17.9(325)	18.0(325)	2.59
Dicamba + clodinafop	120+60	7.4(59)	1.5(2.0)	1.22(0.6)	6.62(61)	7.89(62)	4.72
Dicamba + clodinafop	240+60	8.4(73)	2.0(5.9)	1.05(0.1)	8.73(79)	8.90(79)	4.70
Dicamba + sulfosulfuron + S**	120+25	2.5(6.9)	3.7(15.0)	1.03(0.1)	4.61(21)	4.68(22)	4.98
Clodinafop	60	2.1(4.7)	1.0(0.0)	11.36(128)	2.10(4.7)	11.5(133)	4.45
Sulfosulfuron + S **	25	1.6(2.1)	2.5(6.0)	5.15(27.4)	2.93(8.1)	6.04(35)	4.77
Weedy Check	-	13.1(175)	11.2(128)	7.59(57.6)	17.3(303)	19.00(361)	2.28
LSD (=0.05)		1.33	1.50	0.88	1.54	1.39	0.24

* Original values given in parentheses are square root transformed {($\sqrt{x+1}$)} for statistical analysis, **S= Cationic surfactant (Leader mix) 1250 ml/ha

demonstrated that auxin herbicides (2,4-D + mecoprop + dicamba) reduced the efficacy of fenoxaprop when applied as tank mixture or when these broad-leaf herbicides were applied 14 days before fenoxaprop application. However, efficacy was not affected when applied either 3 weeks before or >3 days after fenoxaprop application. Similarly, Olson and Nalewaja, 1981 reported that wild oat control with diclofop at 1.0 kg/ha was reduced from 96% to 14% when tank mixed with dicamba. They also reported that MCPA antagonism of wild oat control with diclofop increased as the post treatment temperature increased from 10 to 30°C. Antagonism of tank mix combinations of grass herbicides (clodinafop or fenoxaprop) with broad-leaf herbicides (2, 4-D or metsulfuron) is also reported by Mathiassen and Kudsk (1998) and Yadav *et al.*(2009).

Sulfosulfuron efficacy was not affected by dicamba tank mix combination (Fig.1). Contrary to it, many research workers (Damalas and Eleftherohorinos 2001, Hart and Wax 1996) have reported reduced efficacy of sulfonyl urea (rimsulfuron and primisulfuron and imidazolinone (imazethapyr) herbicides with tank mixing of dicamba. This differential response might be due to difference in the nature of weed or herbicide or use of surfactant or environmental conditions.

Damalas and Eleftherohorinos (2001) observed 17 and 43%, lower control of Johnsongrass with tank mix application of dicamba (280 g/ha) with rimsulfuron and primisulfuron compared to their application alone. Hart and Wax, (1996) also reported dicamba antagonizing grass weed control with imazethapyr by reducing foliar absorption. Using MSO (methylated seed oil) instead of NIS (non-

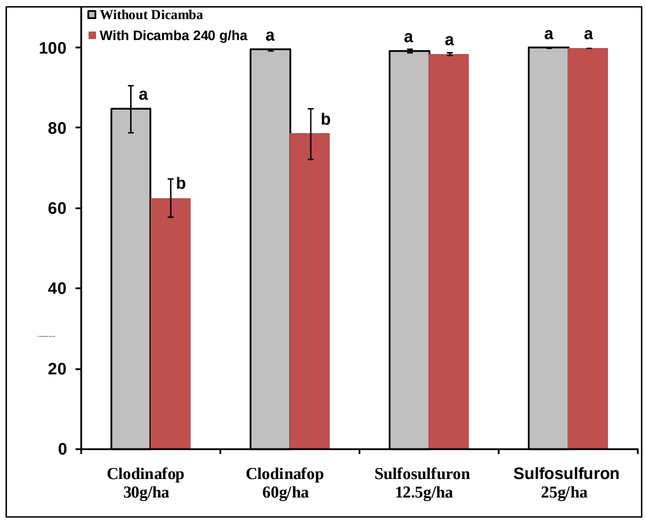

Fig. 1. Reduction in fresh biomass of *P. minor* in comparison to untreated control with clodinafop and sulfosulfuron alone and in tank mix combination with dicamba. Vertical bars represent ± SEM (6 observations). Means having the same letter were not significantly different at P=0.05 using the "paired t-test".

ionic surfactant) prevented antagonism when Na- dicamba was applied at 70 and 140 g/ha and reduced the severity of the antagonism at greater application rates by greatly increasing absorption compared to NIS. The addition of AMS (ammonium sulfate) to spray mixture, maintained imazethapyr at normal absorption and retention rates, and thus prevented any antagonism of grass control. It has also been reported that AMS overcomes the decreased herbicide activity due to antagonism caused by the presence of metal cations (Ca, Na, K and Mg) in water used as spray solution (Nalewaja and Matysiak 1993, McMullen, 1994, Nalewaja *et al*. 1995).

Based on this study, dicamba alone was effective against broad-leaved weeds and in combination with sulfosulfuron provided broad-spectrum weed control. Dicamba antagonized the grass weed control with clodinafop. However, in tank mix combination, the efficacy against broad-leaf weeds was not affected. Damalas (2004) also reported that antagonism is generally observed more often than synergism, occurs more frequently in grass weeds rather than broad-leaved weeds and also in mixtures where the companion herbicides belong mainly to different chemical families. For effective management of diverse weed flora, combination of herbicides, either as ready mixture or tank mixture, if compatible or as sequential application, if not compatible, are needed (Singh *et al.* 2005, Yadav *et al.* 2009, Singh *et al.* 2010). To avoid antagonism clodinafop with dicamba should be used in sequential application. However, further research is needed to identify the optimum time interval between the sequential applications to effectively control the grass weeds as herbicide application timing and sequence may also alter the herbicide compatibility (Dernoeden and Fidanza 1994).

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