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Surfactant influence on efficacy of herbicides in barley

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ABSTRACT

Field experiment was conducted at Agricultural Research Farm, Banaras Hindu University during winter seasons of 2014-15 and 2015-16 to evaluate the effect of herbicides alone or as mixture with or without nonionic surfactant on broad-leaf weeds in barley (*Hordeum vulgare* L.). Post-emergence application of premix formulation of metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha + surfactant at 0.2% proved most effective against *Anagalis arvensis* L., *Chenopodium album* L., *Melilotus alba* L., *Solanum nigrum* L. and *Rumex dentatus* L. Maximum reduction in population and dry weight of weeds, and higher weed control efficiency (63.2%), yield attributes and yield (3.5 t/ha) of barley were recorded in metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha + surfactant at 0.2% applied as post-emergence.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an ancient cereal grain, which can grow in a wide range of environments than any other cereal, including extremes of latitude, longitude, and high altitude. In India, during 2014-15,barley occupied nearly 0.67 million hectare area producing nearly 1.63 million tons grain, with a productivity of 2.4 t/ha (Anonymous 2015). Presently, 25-30% of total barley produced is used in the manufacturing of malt extract, which is further utilized for brewing, distillation, baby foods, coca-malt drinks, and medicinal syrups. Amongst the factors, limiting barley production, weeds are an important biotic stress affecting crop productivity. Lack of effective weed control measures and basic knowledge of weed management in barley have emerged as the limiting factor in barley production (Duwayri *et al*.1988). Phenoxy herbicides, such as 2,4-D is a widely used chemical for control of broad-leaf weeds in barley but prolonged use of 2,4-D for several years leads to reduced efficacy of 2,4-D especially against hard to control broad-leaf weeds such as *Rumex dentatus* L., *Rumex spinosus* L., and *Malva parviflora.* Recently, *Rumex dentatus* has evolved resistance against metsulfuron, pyroxsulum and mesosulfuron + iodosulfuron in wheat. Proactive approach using herbicide mixture with different mode of action can be an effective way to prevent evolution of resistance biotypes in predominant weeds. Metsulfuron-methyl is a sulfonylurea herbicide and has both, pre- and post-emergence activity for control of broad-leaf weeds and can suppress some annuals. Studies indicated that barley can metabolize metsulfuron-methyl (Anderson *et al.* 1989), thus may be helpful to reducing the phyotoxicity on plant. Carfentrazone-ethyl has slight edge over metsulfuron-methyl for the control of *Convolvulus arvensis*, *Rumex dentatus* and *Malva parviflora*, but its efficacy was lower on *C. album*, *A. tenuifolius*, *L. aphaca* and *M. indica* compared to metsulfuron-methyl (Walia *et al.* 2010). Use of activator adjuvant is widely accepted to improve efficacy of post-emergence herbicides, which may allow herbicide dosage to be reduced and nonionic surfactant when added as a tank mixture increased the efficacy of post-emergence herbicides (Hosseini *et al.* 2011). Since, no single herbicide controls all broad-leaved weeds, the present study was conducted to evaluate the effect of alone and tank mix application of different herbicide with or without surfactant on weed growth and yield of barley.

MATERIALS AND METODS

The efficacy of alone and tank mix application of different herbicides in reducing weed biomass and effect on crop yield were evaluated during the winter seasons of 2014-15 and 2015-16 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh). The soil of the experimental field was sandy loam in texture, neutral in reaction, low in organic carbon (0.4%) and available nitrogen (196.4 kg/ha), high in available phosphorus (25.6 kg/ha) and medium in available potassium (170.1 kg/ha). The experiment was laid out in a randomized complete block design with 3 replications and 16 treatments. The treatments consisted of 3 rates (15, 20 and 25 g/ha), of metsulfuron-methyl 10% + carfentrazone-ethyl 40% and 2,4-D Na salt at 500 g/ha without and with 0.2% non-ionic surfactant (NIS), alone application of metsulfuron-methyl, carfentrazone-ethyl, isoproturon 1000 g/ha, mixture of isoproturon + 2,4-D sodium salt (1000 + 500 g/ha),weedy check and weed free. Barley variety '*RD2552*' was sown with recommended package and practices except treatments. Herbicides were applied with knapsack sprayer fitted with flat-fan nozzle. The quantity of spray volume was calculated by test run basis. Data on weed density and dry weight was recorded on 60 DAS, and was subjected to square root transfor-mation. Data on weed control efficiency (WCE) was calculated at 60 DAS. The yield attributes were recorded at harvest and yield of barley was recorded after threshing adjusted to 14% moisture content.

RESULTS AND DISCUSSION

Effect on weeds

The major weeds found to infest experimental field were *Anagalis arvensis*, *Chenopodium album*, *Melilotus alba*, *Solanum nigrum* and *Rumex dentatus* among the broad-leaf weeds. Crop was also infested with perennial grass *Cynodon dactylon* L. and sedge, *Cyperus rotundus* L. All the weed control treatments significantly reduced the weed density as compared to the untreated control. Metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha with 0.2% non ionic surfactant (NIS) was most effective and had significantly minimum density of broad-leaf weed species than other treatments, except metsulfuron-methyl + carfentrazone-ethyl at 20 g/ha with surfactant. Alone application of carfentrazone-ethyl at 40 g/ha and metsulfuron-methyl at 4 g/ha with 0.2% NIS were significantly superior to their application without surfactant and also to 2,4-D at 500 g/ha, either applied alone or with NIS. These treatments remained at par with metsulfuron-methyl + carfentrazone-ethyl at 15 and 20 g/ha without NIS. Isoproturon at 1000 g/ha was ineffective in controlling broad-leaf weeds and thus had significantly higher density of weeds. However, when mixed with 2,4-D, it controlled broad-leaf weeds similar to metsulfuron-methyl + carfentrazone-ethyl at 15 and 20 g/ha without NIS (**Table 1)**. The application of 2,4-D + isoproturon was most effective in controlling broad-leaved weeds at all stages except 30 DAS. These results obtained mainly due to the fact that most of the herbicides when applied alone controlled few broad leaf weeds or grassy weeds.

The dry matter accumulation by weeds envisages that it varied in different herbicide treatments. This might be due to the variable density of weeds under different treatments. The maximum reduction in weed dry matter was observed in the treatment metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha + 0.2% NIS and minimum in weedy check. Similar results were obtained by Singh *et al.* (2011)

Table 1. Effect of different herbicides on weeds population at 60 days after sowing (two years mean)

Treatment	Weeds population/m^2						
	Anagalis arvensis	*Chenopodium album*	*Melilotus alba*	*Solanum nigrum*	*Rumex dentatus*	*Cyperus rotundus*	Total weed
Metsulfuron-methyl + carfentrazone-ethyl (15 g/ha)	2.24(4.5)	1.8(3.0)	1.7(2.7)	2.9(8.0)	2.3(5.2)	3.19(9.7)	6.83(46.2)
Metsulfuron-methyl + carfentrazone-ethyl (20 g/ha)	2.04(3.6)	1.7(2.5)	1.6(2.3)	2.8(7.5)	2.2(4.5)	3.03(8.7)	6.52(42.0)
Metsulfuron-methyl + carfentrazone-ethyl (25 g/ha)	1.69(2.3)	1.4(1.5)	1.4(1.7)	2.7(7.0)	2.2(4.3)	2.92(8.0)	6.14(37.2)
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (15 g/ha + 0.2%)	1.91(3.1)	1.5(1.9)	1.5(2.0)	2.7(7.2)	2.1(4.2)	2.97(8.3)	6.31(39.4)
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (20 g/ha + 0.2%)	1.53(1.8)	1.3(1.3)	1.3(1.3)	2.6(6.7)	2.0(3.7)	2.86(7.7)	5.93(34.7)
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (25 g/ha + 0.2%)	1.08(0.6)	1.0(0.7)	1.2(1.0)	2.5(6.2)	1.9(3.2)	2.80(7.3)	5.60(30.4)
Metsulfuron-methyl (4 g/ha)	2.83(7.5)	2.7(7.0)	2.5(6.0)	3.2(9.9)	2.8(7.3)	2.45(5.5)	7.33(53.2)
Carfentrazone-ethyl (20 g/ha)	2.68(6.6)	2.6(6.3)	2.4(5.3)	3.1(9.5)	2.7(6.9)	2.62(6.4)	7.22(51.7)
2,4-D-Na (500 g/ha)	3.03(8.6)	2.9(8.0)	2.7(7.2)	3.2(10.3)	2.9(8.0)	2.27(4.7)	7.55(56.5)
Metsulfuron-methyl + nonionic surfactant (4 g/ha + 0.2%)	2.52(5.8)	2.3(5.0)	2.0(3.7)	3.1(9.2)	2.6(6.3)	2.24(4.5)	6.63(43.5)
Carfentrazone-ethyl + nonionic surfactant (20 g/ha + 0.2%)	2.42(5.3)	2.2(4.7)	1.9(3.3)	3.1(8.9)	2.5(5.9)	2.20(4.3)	6.52(42.0)
2,4-D-Na + nonionic surfactant (500 g/ha + 0.2%)	2.94(8.1)	2.8(7.5)	2.6(6.5)	3.2(10.0)	2.8(7.7)	2.00(3.5)	7.15(50.7)
Isoproturon (1000 g/ha)	3.16(9.5)	3.0(8.50)	2.8(7.83)	3.3(10.8)	3.0(8.5)	2.12(4.0)	7.59(57.2)
Isoproturon + 2,4-D-Na (1000 + 500 g/ha)	2.31(4.8)	2.1(4.0)	1.8(3.0)	3.0(8.5)	2.4(5.5)	1.78(2.7)	5.92(34.5)
Weedy check	3.49(11.6)	3.2(10.0)	3.0(9.0)	3.6(12.5)	3.1(9.5)	3.8(14.2)	9.06(81.7)
Weed free	0.71(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.71(0.0)	0.71(0.0)
LSD (p=0.05)	0.50	0.40	0.51	0.23	0.28	0.37	0.44

Table 2. Effect of herbicide on weed dry weight, weed control efficiency, yield attributes, and yield of barley (two years mean)

Treatment	Weeds weight (g/m^2)	WCE (%)	Ear heads/m^2	Grains (no./ear)	Test weight (g)	Grain yield (t/ha)
Metsulfuron-methyl + carfentrazone-ethyl (15 g/ha)	12.6	51.2	332	39	31.1	2.9
Metsulfuron-methyl + carfentrazone-ethyl (20 g/ha)	11.9	53.8	341	40	32.2	3.1
Metsulfuron-methyl + carfentrazone-ethyl (25 g/ha)	11.2	56.5	348	41	32.8	3.2
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (15 g/ha + 0.2%)	11.8	56.6	352	42	31.6	3.0
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (20g/ha + 0.2%)	10.1	60.1	356	46	32.6	3.3
Metsulfuron-methyl + carfentrazone-ethyl + nonionic surfactant (25g/ha + 0.2%)	9.5	63.2	358	45	33.8	3.5
Metsulfuron-methyl (4 g/ha)	15.4	39.2	333	37	30.5	2.9
Carfentrazone-ethyl (20 g/ha)	14.3	44.5	336	38	31.2	2.8
2,4-D-Na (500 g/ha)	16.4	36.4	330	35	29.9	2.7
Metsulfuron-methyl + nonionic surfactant (4 g/ha + 0.2%)	14.1	45.3	337	38	31.0	3.2
Carfentrazone-ethyl + nonionic surfactant (20 g/ha + 0.2%)	13.4	48.1	340	44	31.7	3.0
2,4-D-Na + nonionic surfactant (500 g/ha + 0.2%)	14.6	43.4	290	36	30.2	2.9
Isoproturon (1000 g/ha)	22.1	14.4	284	34	29.4	2.7
Isoproturon+2,4-D-Na (1000 + 500 g/ha)	15.0	41.9	300	37	30.9	2.8
Weedy check	25.8	0.0	271	33	28.6	2.4
Weed free	0.00	100	349	45	34.8	3.7
LSD (p=0.05)	0.25	2.7	8.6	1.2	1.6	0.01

WCE-Weed control efficiency

who found that the use of tank mix application of metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha with surfactant reduced the weed dry weight. The lower doses of application of herbicide at 15, 20 g/ha with surfactant proved similarly to its mixture at higher rates that is at 20 and 25 g/ha without surfactant, respectively. It indicates that use of non-ionic surfactant was effective in improving herbicide efficacy and reducing rate of herbicide mixtures (Rashed *et al.* 2011). Weed dry weight was significantly reduced under herbicide treatments due to decrease in weed population (Punia *et al.* 2011). The highest weed dry matter was recorded with the application of isoproturon which might be due to dominance of broad-leaf weeds in experimental crop.

Weed control efficiency (WCE) reflects the relative efficiency of weed control practices in reducing weed growth over weedy check. Among various weed control treatments, application of metsulfuron-methyl + carfentrazone-ethyl at 25 g/ha + 0.2% NIS recorded higher WCE than other weed control treatments. The results were in conformity with Ram *et al.* (2009) who reported that the higher WCE might be due to better weed control, which was associated with reduction in weed density and weed dry weight. The lowest WCE was found with the application of isoproturon owing to its poor efficacy against broa-leaf weeds.

Effect on crop

All the weed control practices significantly influenced the yield attributes as compared to weedy check and sole application of isoproturon. Application of metsulfuron-methyl and carfentrazone-ethyl at 25 g/ha recorded maximum ear heads/m^2, number of grains/ear head, test weight and ultimately the yield. Application of herbicide mixture at higher rates at 20 and 25 g/ha without surfactant remained at par with lower rates at 15g and 20g/ha with surfactant (**Table 2**).This could be due to higher WCE in these treatments, which showed minimum competition from weeds resulting in higher crop dry matter production and yield attributing characters. Consequently, the grain yield also improved with increase in yield attributes under the treatment.

This study confirmed the role of herbicide mixture in managing complex weed flora in barley and also the role of surfactant in reducing rate of herbicides. Thus, pre-mix formulation of metsulfuron-methyl + carfentrazone-ethyl at dose of 20 g/ha or 25 g/ha + 0.2% NIS is an alternate to their individual use for managing weeds in barley.

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