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Reducing Herbicide Dose in Combination with Sorghum Water Extract for Weed Control in Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field study was conducted to investigate the possibilities of reducing the dose of Mesosulfuron-Methyl (Atlantis 3 WG) and Bromoxinil + MCPA (Buctril Super, 60 EC) in combination with sorgaab (Sorghum water extract) for weed control in wheat. Mesosulfuron Methyl (Atlantis 3 WG) @ 10.8 g a. i. ha^{-1} and Bromoxinil + MCPA (Buctril Super, 60 EC) @ 375 g a.i. ha^{-1} each alone and reduced dose of each in combination with sorgaab were sprayed at 30 days after sowing (DAS); whereas, Bromoxinil + MCPA (Buctril-M, 40 EC) @ 500 g a. i. ha^{-1} and Isoproturon (Tolkan, 50W) @ 1000 g a.i. ha^{-1} alone and half dose of each in combination with sorgaab @ 12 L ha^{-1} were kept as standard treatments and a weedy check as control was maintained. Results of the study showed that Mesosulfuron Methyl (Atlantis, 3 WG) @ 10.8 g a. i. ha^{-1} sprayed at 30 DAS was the most effective treatment in reducing total weed density and dry weight up to 84.75 and 86.48%, respectively and increasing grain yield by 19.47% over control. It was followed by its reduced dose @ 6.25 g a.i. ha^{-1} combined with sorgaab @ 12 L ha^{-1} that reduced total weed density by 75.89% and total weed dry weight by 79.28% and increased grain yield by 18.65% over control. Economic analysis showed that reduced dose (up to 50%) of Mesosulfuron Methyl (Atlantis, 3 WG) and Isoproturon (Tolkan, 50W) combined with sorgaab @ 12 L ha^{-1} sprayed at 30 DAS were the economical treatments than their full dose alone although weed suppression was less; while reduced dose of Bromoxinil + MCPA was not economical.

Key Words: Sorgaab; Herbicides; Weed control; Wheat; Allelopathy

INTRODUCTION

Enormous expansion in herbicide usage is expected in near future in Pakistan because of the realization of the losses caused by weeds and enhanced focus of private sector on herbicide sale. The knowledge regarding herbicides and their usage is generally lacking in Pakistan that leads to hazards like phytotoxicity and increased environmental pollution. Endangered global environment by pesticides (herbicides) has attracted the attention of researchers to find new environment friendly techniques and methods for controlling weeds. One of the possible strategies for reducing or minimizing the use of pesticides (herbicides) may be the use of more natural products and manipulation of allelopathy. It may be utilized to lessen the herbicide usage. Sorghum allelopathy is under active investigation since seventies. Putnum and DeFrank (1979) reported that Sorghum and Sudan grass straw provided 90 and 85% weed biomass inhibition due to release of phytotoxic allelochemicals. Sorghum is a well known allelopathic crop (Putnum & DeFrank, 1983). It possesses a number of water soluble allelochemicals which are known to be phytotoxic to many weeds, however, they may influence crops (Cheema, 1988). Natural allelochemicals can affect the growth of crops and weeds and these effects may be positive or negative depending upon their concentration and type of vegetation (Rice, 1984). Some of the latest researches conducted by Cheema and his associates (Cheema *et al.*, 2002-2003) have suggested that tremendous scope exist for reducing herbicide use in combination with allelopathic Sorghum water extract (sorgaab). Cheema *et al.* (2003) demonstrated that Isopruturon dose could be reduced by 50-60% when combined with sorgaab @ 12 L ha^{-1} for weed control in wheat. In similar studies in maize and cotton, they found that half dose of atrazine (150 g a.i. ha^{-1}) in combination with sorgaab @ 12 L ha^{-1} at sowing gave as effective control as the full dose of atrazine @ 300 g a.i. ha^{-1} (Cheema *et al.*, 2003) and they also observed that 1/3rd dose of Pendimethalin in combination with concentrated sorgaab @ 12 L ha^{-1} gave higher seed cotton yield (72.2%) than full dose of Pendimethalin although weed control was relatively less. The present study was conducted to evaluate two new herbicide formulations, Mesosulfuron methyl (Atlantis, 3 WG) and Bromoxinil + MCPA (Buctrel Super, 60 EC) at half dose combined with sorgaab and at their recommended rates alone for controlling annual narrow + broad leaf weeds and for only broad leaved weeds, respectively in Faisalabad conditions.

MATERIALS AND METHODS

A field experiment was conducted at Ochkaira Farm, University of Agriculture, Faisalabad, during 2002-2003 to determine the feasibility of reducing herbicide dose in combination with sorgaab for weed control in wheat. The experiment was laid out in RCBD with four replications. Net plot size was (5 x 2 m).

Wheat cv. watan was sown in 22.5 cm apart lines with tractor drawn combined (seed & fertilizer) drill. Nitrogen and Phosphorus were applied @ 22.5 and 57.5 kg ha^{-1} at sowing. Remaining requirements of fertilizer were fulfilled by alternate irrigation with treated sewerage water. Sorgaab (Sorghum water extract) was prepared following the procedure developed by Cheema *et al.* (2000) at weed science-allelopathy labortary U.A.F. Mesosulfuron Methyl (Atlantis, 3 WG) @ 10.8 g a.i. ha^{-1} and Bromoxinil + MCPA (Buctrel Super, 60 EC) @ 375 g a.i. ha^{-1} each alone and reduced dose (1/2) of each in combination with sorgaab were sprayed at 30 days after sowing (DAS);whereas, Bromoxinil + MCPA (Buctril-M, 40 EC) @ 500 g a.i. ha^{-1} and Isoproturon (Tolkan, 50W) @ 1000 g a.i. ha^{-1} alone and half dose of each in combination with sorgaab @ 12 L ha^{-1} were kept as standard treatments and a weedy check as control was maintained. The sorgaab and herbicides were sprayed according to the treatments at 30 DAS with Knapsack hand sprayer. Volume of spray was determined by calibration. Data on weed density and weed biomass were recorded at 40 and 60 DAS from randomly selected two quadrates (50 x 50 cm^2) from each experimental plot. The dry weight of weeds was taken after drying in an oven till a constant weight was achieved. Data on wheat plant height, spikelets per spike, number of grains per spike were recorded from 20 randomly selected samples taken from each plot and then their average was taken. Fertile tillers (m^{-2}) were recorded from randomly selected sites from each plot. A random sample of grains was taken from the produce of each plot to take thousand grains weight. Thousand grains were counted manually and weighed on an electric balance. Grain yield was recorded on whole plot basis. Crop was harvested, tied into bundles in respective plots, biological yield of sundried samples were recorded from each treatment and each experimental plot was manually threshed to determine grain yield and then converted into Mg ha^{-1}. Data collected on different parameters were analyzed statistically using Fisher's analysis of variance technique and least significant difference test at 0.05 probability was used to compare differences among the treatment's means (Steel & Torrie, 1984). Economic analysis of the treatments was performed to determine the most economical treatment (Byerlee, 1988).

RESULTS AND DISCUSSION

Predominant weeds at the experimental site were *Avena fatua* (Wild oat). *Chenopodium album* (Lambsquarter). *Fumaria parviflora* (Fumatory) and *Cyprus*

Table I. Effect of various herbicides alone and in combination with sorgaab on weed density and dry weight (g m^{-2}) in wheat (*Triticum aestivum* L.) at 60 DAS

Treatments		Total weed density	Total weed Dry weight
T1	Control	45.125a	4. 44a
T2	Mesosulfuron methyl (Atlantis 3WG) @ 10.8 g a.i. ha^{-1} at 30 DAS	6.880g (84.75)	0. 60d (86.48)
T3	Bromoxinil + MCPA (Buctril super 60EC) @ 375 g a.i. ha^{-1} at 30 DAS	10.630de (76.44)	1. 11c (75.00)
T4	Bromoxinil + MCPA (Buctril M 40EC) @ 500 g a.i. ha^{-1}at 30 DAS	12.630c (72.01)	2. 34b (47.30)
T5	Isopruturon (Tolkan 50W) @ 1000 g a.i. ha^{-1} at 30 DAS	9.630ef (78.66)	1. 29bc (70.95)
T6	Mesosulfuron methyl (Atlantis 3WG) 6.25 g a.i. ha^{-1} + Sorgaab @ 12 L ha^{-1} at 30 DAS	10.880cde (75.89)	0. 92c (79.28)
T7	Bromoxinil + MCPA (Buctril super 60EC) @ 215 g a.i.ha^{-1} + Sorgaab @ 12 L ha^{-1} at 30 DAS	11.630cd (74.23)	3. 91a (11.94)
T8	Isopruturon (Tolkan 50W) @ 500 g a.i.ha^{-1} + Sorgaab @ 12 L ha^{-1} at 30 DAS	8.750f (80.60)	1. 047c (76.42)
T9	Bromoxinil + MCPA (Buctril M 40EC) 250 g a.i. ha^{-1} +Sorgaab @ 12 L ha^{-1} at 30 DAS	17.630b (60.93)	3. 70a (16.67)
	LSD	1.886	0. 386

Figures given in parenthesis show percent decrease over control
Means with different letters differ significantly at 5% level of probability
DAS: Days after sowing

Table II. Effect of various herbicides alone and in combination with sorgaab on yield and yield components of wheat

Treatments	Plant Height (cm)	Fertile Tillers m^{-2}	Spikelets Per spike	Grains per spike	1000 grain weight	Grain yield (Mg ha^{-1})
T1	87.30^{NS}	243.58d	13.92d	38.54d	36.36^{NS}	3.518d
T2	86.67	270.09ab	16.08a	45.02a	37.87	4.203a (19.47)
T3	89.33	263.47abc	14.95bc	42.48abc	38.86	3.900b (10.86)
T4	87.65	254.73cd	15.22abc	42.22abc	39.39	3.850b (9.44)
T5	89.29	256.66bcd	15.54ab	45.14a	38.21	4.135a (17.54)
T6	87.74	266.87abc	15.26abc	43.90ab	37.05	4.174a (18.65)
T7	87.52	249.45d	14.89bc	41.31bcd	38.60	3.800bc (8.02)
T8	87.66	271.42a	15.95a	43.97ab	37.22	4.143a (17.77)
T9	88.12	247.34d	15.07abc	40.25cd	37.37	3.700c (5.17)
LSD		13.92	0.55	3.11		0.154

Figures given in parenthesis show percent decrease over control
Means with different letters differ significantly at 5% level of probability

rotundus (purple nutsedge) while few plants of *Cornopus didymus* (Swine cress). *Rumex dentatus* (Broad leaved dock). *Trigonella polycerata* (Trefoil) and *Phalaris minor* (Canary grass) were also observed. All the treatments significantly suppressed total weed density (Table I) as compared to control. Mesosulfuron methyl (Atlantis, 3WG) @ 10.8 g a.i. ha^{-1}, and 1/2 dose of Isoprutoron @ 500 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1} at 30 DAS were most effective treatments causing 57-85 and 73-81% reduction in total weed density, respectively. Half dose of Isoprutoron @ 500 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1} at 30 DAS was statistically at par with full dose of Isopruturon @ 1000 g a.i. ha^{-1} at 30 DAS in reducing total weed density. Similarly, full dose of bromoxinil + MCPA (Buctril super, 60EC) and its reduced dose combined with sorgaab @ 12 L ha^{-1} were statistically at par in reducing total weed density (36-76%). These results indicate that herbicide dose can be decreased by 50% when used in mixture with sorgaab @ 12 L ha^{-1}. These results are in conformity to Cheema *et al.* (2003) who reported 73% reduction in total weed density by sorgaab @ 12 L ha^{-1} + MCPA @ 150g a.i. ha^{-1} at 30 DAS.

Data regarding dry weight of weeds revealed that all the treatments significantly reduced total weed dry weight as compared to control, but Mesosulfuron methyl (Atlantis, 3 WG) @ 10.8 g a.i ha^{-1} was the most effective treatment in reducing total weed dry weight by 86% recorded at 60 DAS. This was due to better suppression of both annual narrow and broad leaved weeds. It was followed by Mesosulfuron methyl (Atlantis, 3WG) @ 6.25 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1}, 1/2 dose of Isopruturon + sorgaab @ 12 L ha^{-1}, Bromoxinil + MCPA (Buctril-Super, 60EC) @ 375 g a.i. ha^{-1} and Isoptruturon (Tolkan, 50W) @ 1000 g a.i.ha^{-1}, and these were statistically on par with one another in reducing total weed dry weight at 60 DAS.

Wheat grain yield was significantly increased in all the treatments as compared to control in the range of 5-20%. The maximum grain yield (4.203 Mg ha^{-1}) was obtained in Mesosulfuron methyl (Atlantis, 3 WG) @ 10.8 g a.i. ha^{-1}, and it was statistically at par with Isoptruturon (Tolkan, 50W) @ 1000 g a.i. ha^{-1}, Mesosulfuron methyl (Atlantis, 3WG) @ 6.25 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1}, and 1/2 dose of Isopruturon + sorgaab @ 12 L ha^{-1} in increasing grain yield of wheat. Similarly treatment Bromoxnil + MCPA (Buctril super, 60Ec) @ 375 g a.i. ha^{-1}, Bromoxnil + MCPA (Buctril-M, 40Ec) @ 500 g a.i. ha^{-1}, and Bromoxinil + MCPA (Buctril super, 60EC) @ 215 g a.i. ha $^{-1}$ + sorgaab @ 12 L ha^{-1} were statistically at par in increasing grain yield of wheat. The increase in grain yield was due to better weed control in these treatments. Weed inhibition was due to suppressive effect of sorgaab and herbicides that possibly helped more material availability for plant growth and development, more photosynthetic area and more

Table III. Economic analysis

	T1	T2	T3	T4	T5	T6	T7	T8	T9	Remarks
Total grain yield	3518	4203	3900	3850	4135	4174	3800	4143	3700	Kg ha^{-1}
Adjusted yield	3166.2	3782.2	3510	3465	3721.5	3756.6	3420.0	3728.7	3330	To bring at Farmer's level (10%)
Gross incom	27704.25	33098.62	30712.50	30318.75	32563.12	32870.25	29925.00	32626.12	29137.5	Rs. 300 / 40 kg
Cost of Herbi-cide	----	1237	547	700	750	716	313	375	350	Cost vary with herbicide
Cost of sorgaab	-----	-----	-----	----	----	50	50	50	50	Expenditure on preparation of 12 L Sorgaab Rs. 50/-
Spray application cost	----	100	100	100	100	100	100	100	100	Rs.100/man (one man per day ha^{-1})
Sprayer rent	---	50	50	50	50	50	50	50	50	Rs. 50 / spray
Cost that vary	---	1387	697	850	900	916	513	575	550	Rs. ha^{-1}
Net benifits	27704.25	31711.62	30015.5	29468.75	31663.12	31954.25	29412.00	32076.12	28587.5	Rs. ha^{-1}

Table IV. Marginal and dominance analysis

Treatments	Cost that Vary (Rs. ha^{-1})	Net benefits (Rs. ha^{-1})	Marginal rate of return(%)
T1 = Control	0	27704.25	0
T7= Bromoxinil + MCPA (Buctril super 60Ec) @ 215 g a.i ha^{-1} + Sorgaab @ 12 L ha^{-1}	513	29412.00	332.89
T9= Bromoxinil + MCPA (Buctril M 40EC) @ 250 g a.i + Sorgaab @ 12 L ha^{-1}	550	28587.50	D
T8= Isopruturon (Tolkan 50W) @500 g a.i + Sorgaab @ 12 L ha^{-1}	575	32076.12	4296.96
T3= Bromoxinil + MCPA (Buctril super 60EC) @ 375 g a.i. ha^{-1}	697	30015.5	D
T4= Bromoxinil + MCPA (Buctril M 40EC) @ 500 g a.i. ha^{-1}	850	29468.75	D
T5= Isopruturon (Tolkan 50 WP) @ 1000 g a.i. ha^{-1}	900	31663.12	D
T6= Mesosulfuron methyl (Atlantis 3 WG) @ 6.25 g a.i. ha^{-1} + Sorgaab @ 12 L ha^{-1}	916	31954.25	D
T2 =Mesosulfuron methyl (Atlantis 3 WG) @ 10.8 g a.i. ha^{-1}	1387	31711.62	D

D = Dominated

$$\text{Marginal rate of return (MRR\%)} = \frac{\text{Change in net benefit}}{\text{Chang in cost}} \times 100$$

Cost that vary =The cost that is incurred on variable inputs in the productionof a paticular commodity.

translocation of photosynthates towards reproductive parts that ultimately increased grain yield (Salisbury & Ross, 1978). So, the reduced dose (up-to 50%) of Mesosulfuron methyl (Atlantis, 3WG), Isopruturon (Tolkan, 50W) and Bromoxinil + MCPA (Buctril super, 60EC) are as effective as their full dose in increasing grain yield. These results are in lines with Cheema *et al.* (1997). They reported 14% more grain yield than control due to single spray of sorgaab at 30 DAS. The increase in grain yield with reduced herbicide rate combined with allelopathic crop water extract was also reported by Cheema *et al*. (2003). These results supported the idea of reducing herbicide dose in combination with sorgaab.

Economic analysis showed that highest net benefits were obtained in Isopruturon @ 500 g a.i.ha^{-1} + sorgaab @ 12 L ha^{-1} (RS. 32516.12). This was followed by Mesosulfuron methyl (Atlantis, 3 WG) @ 6.25 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1} (Rs. 31954.25); whereas, Mesosulfuron methyl (Atlantis, 3WG) @ 10.8 g a.i. ha^{-1}, and Isopruturon (Tolkan, 50W) @ 1000 g a.i ha $^{-1}$ were not economical treatments due to higher cost of the respective herbicide although they cause more weed suppression. Highest marginal rate of return (4296.96%) was found in 1/2 dose of isopruturon (Tolkan, 50W) @ 500 g a.i. ha $^{-1}$ + sorgaab @ 12 L ha $^{-1}$. This was followed by Bromoxinil + MCPA (Buctril super, 60 EC) @ 215 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1} with (332.89%) marginal rate of return; while all other treatments were dominated and hence uneconomical. Half (1/2) dose of isopruturon (Tolkan, 50W) @ 500 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1}) was the best and economical treatment with higher net benefits and marginal rate of return. It was followed by Mesosulfuron methyl (Atlantis, 3WG) @ 6.25 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1}. Based on these findings, it can be suggessted that Mesosulfuron methyl (Atlantis, 3WG) and Isopruturon (Tolkan, 50W) dose may possibly be reduced up to 50% when combined with sorgaab @ 12 L ha^{-1}. The reduction in herbicide dose may also decrease the cost of production on one hand and strengthen efforts for protecting the environment on sustainable basis.

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