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WEED MANAGEMENT IN WHEAT THROUGH COMBINATION OF ALLELOPATHIC WATER EXTRACT WITH REDUCED DOSES OF HERBICIDES

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ABSTRACT

Allelopathy has potential to tackle concerns associated with indiscriminate use of synthetic herbicides. In order to reduce herbicide usage, allelopathic crop water extracts with reduced herbicides doses were tested for weed management in wheat during the year 2005-06 at research farm of the Department of Agronomy, University of Agriculture, Faisalabad. Sorghum and sunflower water extracts (WE) combinations each at 18 L ha^{-1} with reduced doses by 70% of mesosulfuron + idosulfuron (Atlantis 3.6 WG), mesosulfuron + idosulfuron (Atlantis 12 EC), metribuzin + fenoxaprop (Bullet 38 SC), bensulfuron + isoproturon (Cleaner 70 WP) and metribuzin (Sencor 70 WP) were compared at their label doses which were sprayed alone 30 days after sowing for weed control in wheat. Label dose of isoproturon was used as a standard treatment and a weedy check was also maintained. Overall weed density, dry weed biomass and wheat grain yield were significantly influenced by different combination of plant water extracts with reduced (70%) doses of synthetic herbicides. Combination of sorghum + sunflower WE each at 18 L ha^{-1} with reduced dose of metribuzin + fenoxaprop significantly reduced dry weed biomass by 92% comparable to label dose of mesosulfuron + idosulfuron (93%). Treatment combination of sorghum + sunflower WE each at 18 L ha^{-1} with reduced dose of metribuzin + fenoxaprop by 70% produced maximum (2.82 t ha^{-1}) grain yield with 34 % increase over control and it was significantly higher than its label dose to the extent of 17% increase in grain yield.

Key words: Wheat, allelopathic crop water extracts, weed management.

INTRODUCTION

Allelopathy is existing in nature since centuries, but it has drawn special attention over couple of decades. Recently, it is exploited as a weed control strategy, alternative to the synthetic chemical herbicide

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(Bhowmik and Inderjit, 2003; Jabran *et al.*, 2008). It is environmentally safe, can conserve the available resources and also may mitigate the problems raised by synthetic chemicals (Rizvi and Rizvi, 1992; Duke *et al.*, 2001).

Sorghum (*Sorghum bicolor* L.) is one of the potential allelopathic crop (Jabran *et al.*, 2010a,b) containing a large number of secondary metabolites. Like sorghum, sunflower (*Helianthus annuus* L.) also has a strong allelopathic potential by which it can actively influence the growth of surrounding plants (Azania *et al.*, 2003). About 125 allelochemicals from different cultivars of sunflower, phytotoxic towards many weed species were isolated by Macias *et al.*, (2002). These chemicals are highly water soluble, can be released through root exudation, leaching from plants by rain, or decomposition of residues (Rice, 1984) effects of which depend upon species; concentration (Cheema and Ahmad, 1992) their movement, fate and persistence in soil (Inderjit *et al.*, 2001). These are also selective like synthetic herbicides (Weston, 1996). This characteristic could be used in weed management programmes and allelopathic crops may help in the development of biological herbicides.

Weeds must be controlled up to 80% or more depending upon the nature of the weeds and the extent of infestation to reduce the losses caused by weeds and to manage it to the economic threshold level. On average weeds cause 20-30% losses in different crops in Pakistan. Losses due to weeds exceed beyond Rs. 120 billion on national level, whereas wheat alone accounts for more than 30 billion. Losses due to weeds in major cereal crops of Pakistan exist in the range of Rs.40, 30 and 4 billion for rice, wheat and maize, respectively (Anonymous, 2005). Increasing problems related to weed control, such as herbicide resistant weed biotypes and residual effects of herbicides, increase the demand for organic farming, and increasing public concerns on environmental pollution issues require alternative farming systems which are less dependent on pesticide or based on naturally occurring compounds (Singh *et al.*, 2003; Waller, 2004; Jabran *et al.*, 2010a,b).

Allelopathy is an approach, being utilized in agriculture in various ways i.e. intercropping, allelopathic stubble mulches, allelopathic crops in rotation and inter/mixed cropping systems and aqueous extracts of allelopathic crops as spray (Fortney and Foy, 1985; Cheema, 1988; Narwal, 2000). An important approach is to use foliar sprays of different allelopathic crop water extracts for inhibiting weeds in field crops (Iqbal, 1997; Cheema and Ahmad, 1992; Jabran *et al.*, 2008 & 2010a, b). Extracts of many plant species can be successfully used as bioherbicide (Marwat *et al.* 2008) and thus the herbicides use could be reduced by combining the allelopathic water extracts with lower doses of herbicides (Jabran *et al.*, 2008 & 2010a,b). Mesosulfuron methyl @ 10.8 g a.i. ha^{-1} and ½ dose of isoproturon @ 500 g a.i. ha^{-1} + sorgaab @ 12 L ha^{-1} at

30 DAS were found most effective in reducing total weed density by 57-85% and 73-81%, respectively (Sharif *et al.*, 2005). Reduction in weed biomass and increase in wheat yield was observed by the application of sorghum (*Sorghum bicolor* L.) water extracts (Cheema *et al.*, 2003). Similar observations were made in other crops (Jabran *et al.*, 2008 & 2010a).

The recommended dose of isoproturon, for weed control in wheat, has been reduced by 50-60% if used in combination with sorgaab at 12 L ha^{-1} (Cheema *et al.*, 2003). Sorgaab @ 6 or 12 L ha^{-1} applied in combination with a low rate of sulfosulfuron (15 g a.i. ha^{-1}) at 30 DAS reduced *Avena fatua* L. density by 78-92% and dry weed biomass by 72-98% (Jamil *et al.*, 2007). One spray of sorgaab @ 12 L ha^{-1} mixed with sulfosulfuron (½ dose, @ 15 g a.i. ha^{-1}) at 30 DAS suppressed *Phalaris minor* L. density by 82-91% and dry weed biomass by 86-87%.

The corresponding suppression in weed density and dry weed biomass with a full dose of sulfosulfuron was 91-95% and 97-100%. Grain yields of wheat from treatments with sorgaab in combination with low doses of sulfosulfuron were the same as the recommended dose of sulfosulfuron (Jamil *et al.*, 2007). A large number of studies on allelopathy have been conducted in Pakistan; however, activities related to weed control in wheat by reduced doses of herbicides in combination with allelopathic water extracts are still not well documented internationally. Therefore, the aim of this study was to evaluate the effect of sorghum and sunflower water extracts with reduced doses of some early post emergence herbicides for weed control in wheat.

MATERIALS AND METHODS

Site and Soil

A one year field study was conducted at research farm, Department of Agronomy, University of Agriculture, Faisalabad (31.25° N, 73.09° E, and 184 m), Pakistan, during the year 2005-06. The soil type at the experimental site was sandy clay loam.

Crop husbandry

Wheat variety "Inqalab-91" was planted on a well prepared seed bed in 22 cm spaced rows with single row hand hoe using seed rate at 125 kg ha^{-1}. A basal dose of fertilizer @ 100 kg ha^{-1} N and 85 kg ha^{-1} P_2O_5 was used in the form of urea and diammonium phosphate, respectively. Half of the nitrogen and full dose of the phosphorus were applied at the time of sowing, while remaining half was applied at first irrigation. First irrigation was given after twenty days after sowing and subsequent irrigations were adjusted according to the climatic conditions and need of the crop.

Experimental details

The experiment was laid out in randomized complete block design (RCBD) with four replications in plots measuring 7 x 1.98 m^2. The study comprised different combinations of allelopathic water extracts and reduced doses of herbicides (70%) viz. Sorghum and sunflower WE tank mixed with bensulfuron + isoproturon (Cleaner 70 WP) @ 315 g a. i. ha^{-1}, metribuzin (Sencor 70 WP) @ 52.5 g a.i. ha^{-1}, metribuzin + fenoxaprop (Bullet 38 SC) @ 57 g a.i. ha^{-1}, mesosulfuron + idosulfuron (Atlantis 12 EC) @ 36 g a.i. ha^{-1}, and mesosulfuron + idosulfuron (Atlantis 3.6 WG) at 4.32 g a.i. ha^{-1}. The label doses of isoproturon (50 WP) @ 1000 g a.i. ha^{-1}, mesosulfuron + idosulfuron (Atlantis 3.6 WG) @ 14.40 g a.i. ha^{-1}, mesosulfuron + idosulfuron (Atlantis 12 EC) @ 120 g a.i. ha^{-1}, metribuzin + fenoxaprop @ 190 g a.i. ha^{-1}, bensulfuron + idosulfuron @ 1050 g a.i. ha^{-1} and metribuzin @ 175 g a.i. ha^{-1} alone were sprayed as early post emergence spray 30 days after sowing using knapsack hand sprayer fitted with T-jet nozzle. Isoproturon was used as standard treatment and a weedy check was also maintained.

Measurements

The data on weed density and dry weed biomass were recorded with the help of quadrate measuring 0.25 x 0.25 m^2 randomly placed at two places in respective experimental units at 70 days after sowing. Weeds were counted individually and then by cutting just above the ground for recording fresh weed biomass. Weeds were dried in an oven at 70 $^{\circ}$C for 48 hours for recording dry weed biomass. Ten plants were randomly selected from each plot and their plant height, sterile tillers, fertile tillers, spikelets per spike and grains per spike were noted. Three samples of 1000-grain each were taken randomly from the seed lot of each plot, weighed and then averaged to measure 1000-grain weight. Straw and grain yield were recorded on plot basis by mechanical threshing and converted into t ha^{-1}.

Statistical analysis

Data obtained were analyzed statistically by using statistical package MSTATC (Freed and Scott, 1986). Analysis of variance (ANOVA) was performed by using Fisher's analysis of variance technique while multiple comparisons among treatment means were made using least significant difference (LSD) test at $P \leq 0.05$ (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

All the combination of water extracts and reduced doses (by 70%) of herbicides significantly reduced the weeds density (Table-1). Sorghum + sunflower water extracts (WE) each at 18 L ha^{-1} with 70% reduced dose of metribuzin + fenoxaprop Bullet 38 SC, mesosulfuron + idosulfuron (Atlantis 3.6 WG) full dose, metribuzin (Sencor 70 WP) full dose, sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced dose of Atlantis 3.6 WG, sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced dose of bensulfuron + isoproturon (Cleaner 70 WP), sorghum + sunflower WE + 70% reduced dose of mesosulfuron + idosulfuron (Atlantis 12EC), Bullet 38 SC full dose, and Cleaner 70 WP full dose reduced the *Phalaris minor* density by 92.31, 92.31, 92.31, 88.46, 88.46, 88.46, 88.46 and 84.62%, respectively at 70 DAS over control. All of these treatments of label doses of herbicides and their reduced doses up to 70% were statistically at par with each other. *Coronopus didymus* L. population was also significantly influenced by water extracts in combination with reduced doses of herbicides.

Full dose of Atlantis 3.6 WG at 70 DAS inhibited *Coronopus didymus* L. density by 94% followed by full dose of Sencor 70 WP, Atlantis 12 EC full dose, sorghum + sunflower WE each at 18 L ha^{-1} with 70% reduced dose of Cleaner 70 WP, Bullet 38 SC full dose, sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced dose of Bullet 38 SC, sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced dose of Atlantis 12 EC and sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced dose of Atlantis 3.6 WG, which reduces the *Coronopus didymus* density by 90.6, 90.6, 88.24, 87.25, 87.25, 87.25 and 87.25% respectively, over control, and these were statistically at par with each other.

The population of *Phalaris minor* L. was significantly inhibited by all the treatments, (Table-1) but sorghum + sunflower WE each @ 18 L ha^{-1} with reduced dose of (Bullet 38 SC 70%) and Atlantis 3.6 WG full dose were the best treatments to reduce weed density. Bullet 38 SC reduced dose by 70% in combination with water extracts was statistically at par with full dose of (Atlantis 3.6 WG) due to synergistic effect of allelochemicals with synthetic herbicide.

The range of population reduction was 42 to 92% at 70 DAS over control. Similar results were found in case of *Phalaris minor* L. dry weed biomass (Table-2). Sorghum and sunflower water extracts each @ 18 L ha^{-1} combined with reduced doses by 70% of Cleaner 70WP and Atlantis 12EC gave the maximum reduction in dry weed biomass by 97.96% each, over control and these were followed by combination of allelopathic crop water extracts with reduced dose by 70% of Bullet 38SC which reduced the *Phalaris minor* L. dry weed biomass at 70 DAS, by 96.94% over control.

The results are supported by Cheema *et al.*, (2002a) that herbicide dose can be reduced in combination with allelopathic crop water extracts and by Cheema *et al.*, (2003) who reported that sorghum water extract can be used with reduced dose of herbicide for effective weed control in cotton.

Table-1. Effect of sorghum and sunflower water extracts (70 DAS) with reduced doses of herbicides on weed density in wheat.

Treatments	Rates ha^{-1}	Density of *Phalaris minor*	Density of *Coronopus didymus*
Control (weedy check)	-	6.50 a †	25.5 a
Isoproturon 50 WP	1000 g a.i.	2.0 bc (-69.23)	6.00 b (-76.47)
Bensulfuron+isoproturon (Cleaner 70 WP)	1050 g a.i.	1.0 c (-84.62)	4.75 c (-81.37)
Metribuzin (Sencor 70 WP)	175 g a.i.	0.50 c (-92.31)	2.50 d (-90.6)
Metribuzin + fenoxaprop (Bullet 38 SC)	190 g a.i.	0.75 c (-88.46)	3.25 d (-87.25)
Mesosulfuron + idosulfuron (Atlantis 12 EC)	120 g a.i.	3.75 b (-42.31)	2.50 d (-90.6)
Mesosulfuron + idosulfuron (Atlantis 3.6 WG)	14.4 g a.i.	0.50 c (-92.31)	1.00 e (-96.08)
Sorghum + sunflower WE + Sencor 70 WP	18 L each + 52.5 g a.i.	2.0 bc (-69.23)	4.25 c (-83.33)
Sorghum + sunflower WE + Cleaner 70 WP	18 L each + 315 g a.i.	0.75 c (-88.46)	3.00 d (-88.24)
Sorghum + sunflower WE + Bullet 38 SC	18 L each + 57 g a.i.	0.50 c (-92.31)	3.25 d (-87.25)
Sorghum + sunflower WE + Atlantis 12 EC	18 L each + 36 g a.i.	0.75 c (-88.46)	3.25 d (-87.25)
Sorghum + sunflower WE + Atlantis 3.6 WG	18 L each + 4.32 g a.i.	0.75 c (-88.46)	3.25 d (-87.25)
LSD value at P≤0.05		**2.106**	**0.840**

DAS= Days after sowing; WE = Water extracts.
†=Means not sharing a letter in common differ significantly by LSD at p≤0.05.
Figures in parenthesis show percent decrease in weeds density and dry weed biomass over control.

Dry weed biomass (Table-2) was also significantly influenced by different post emergence herbicides alone and in combination with allelopathic crop water extracts. Sorghum + sunflower WE each @ 18 L ha^{-1} combined with 70% reduced doses of Cleaner 70 WP and Atlantis 12 EC gave the maximum reduction in dry weed biomass by 98 and 98%, respectively, over control, followed by label doses of Sencor 70 WP and allelopathic crop water extracts of sorghum + sunflower each @ 18 L ha^{-1} combined with 70% reduced doses of Bullet 38 SC which reduced the *Phalaris minor* L. dry weed biomass at 70 DAS, by 96, and 95%, respectively, over control, and both of these were statistically at par with each other.

Similarly crop water extracts of sorghum and sunflower each @ 18 L ha^{-1} combined with 70% reduced doses of Sencor 70 WP, mesosulfuron + idosulfuron gave the maximum reduction by 94% in dry weed biomass of *Coronopus didymus* L., and these were followed by label dose of mesosulfuron + idosulfuron and its reduced dose 70% combined with crop water extracts controlled the dry weed biomass by 93% respectively, over control. Dry weed biomass was significantly influenced by all the treatment combinations.

Maximum reduction (94.29%) was found by label dose of Atlantis 3.6 WG and it was statistically at par with reduced Bullet 38SC reduced dose by 70% in combination with plant water extracts (94.29%). Dry weed biomass reduction by the different treatments ranged between 64.29 to 94.29%. These results support the hypothesis that allelopathic water extracts can be used to inhibit weeds or in combination with lower herbicide rate, thereby can considerably decrease their dose by 70 %. More over the concept of having additive or complementarily effects of allelopathic materials in mixture were noted as compared to their separate use. Cheema *et al.*, (2002b) reported that herbicide dose can be reduced in combination with allelopathic crop water extracts.

Grain yield was significantly enhanced by controlling weeds through post emergence herbicides alone and in combination with allelopathic crop water extracts (Table-2). Treatment of sorghum + sunflower WE each @ 18 L ha^{-1} with 70% reduced doses of Bullet 38SC produced maximum (2.82 t ha^{-1}) grain yield with 34.29 % increase over control and it was significantly more than its label dose. The grain yield in other treatments either at their label doses or with allelopathic water extracts were higher than the control and statistically at par with each others. The reason for increase in grain yield over control was the control of weeds and probably the allelopathic effects of crop water extracts promoted the wheat growth which ultimately increases grain yield (Jabran *et al.*, 2008).

The study suggests that reduction of herbicide doses by adding allelopathic crop water extracts would reduce the reliance on the synthetic herbicides. The combination of sorghum + sunflower WE each @ 18 L ha^{-1} with reduced dose by 70% of Bullet 38SC was found to be best treatment which produced maximum grain yield (2.82 t ha^{-1}) with 34.29% increase over control and synthetic herbicide dose reduced was 70%. Reduced herbicide doses in combination with allelopathic crop water extracts would minimize the use of synthetic pesticides, decrease the cost of production and increase the farm income.

Table-2. Effect of sorghum and sunflower water extracts with reduced doses of herbicides on dry weed biomass 70 DAS and grain yield of wheat.

Treatments	**Rates ha^{-1}**	**Dry weed biomass of *Phalaris minor***	**Dry weed biomass of *Coronopus didymus***	**Grain yield (t ha^{-1})**
Control (weedy check)	-	†1.96 a	0.70 a	2.10 c
Isoproturon 50 WP	1000 g a.i.	0.44 b (-77.56)	0.20 bc (-71.43)	2.40 b (+14.29)
Bensulfuron+isoproturon (Cleaner 70 WP)	1050 g a.i.	0.13 def (-93.37)	0.25 b (-64.29)	2.42 b (+15.24)
Metribuzin (Sencor 70 WP)	175 g a.i.	0.07 efg (-46.43)	0.16 bcde (-77.14)	2.55 b (+21.43)
Metribuzin + fenoxaprop (Bullet 38 SC)	190 g a.i.	0.15 d (-92.35)	0.06 def (-91.43)	2.46 b (+17.14)
Mesosulfuron + idosulfuron (Atlantis 12 EC)	120 g a.i.	0.29 c (-85.21)	0.18 bcd (-74.29)	2.38 b (+13.33)
Mesosulfuron + idosulfuron (Atlantis 3.6 WG)	14.4 g a.i.	0.34 c (-82.66)	0.04 f (-94.29)	2.62 ab (+24.76)
Sorghum + sunflower WE + Sencor 70 WP	18 L each + 52.5 g a.i.	0.04 g (-97.96)	0.12 cdef (-82.86)	2.52 b (+20.00)
Sorghum + sunflower WE + Cleaner 70 WP	18 L each + 315 g a.i.	0.10 defg (-94.90)	0.09 cdef (-87.14)	2.60 ab (+23.81)
Sorghum + sunflower WE + Bullet 38 SC	18 L each + 57 g a.i.	0.06 fg (-96.94)	0.04 f (-94.29)	2.82 a (+34.29)
Sorghum + sunflower WE + Atlantis 12 EC	18 L each + 36 g a.i.	0.04 g (-97.96)	0.05 ef (-92.86)	2.56 b (+21.90)
Sorghum + sunflower WE + Atlantis 3.6 WG	18 L each + 4.32 g a.i.	0.14 de (-92.87)	0.05 ef (-92.86)	2.53b (+20.48)
LSD value at P≤0.05		**0.788**	**0.120**	**0.241**

DAS= Days after sowing; WE = Water extracts.
†=Means not sharing a letter in common differ significantly by LSD at p≤0.05.
Figures in parenthesis show percent decrease of dry weed biomass and increase of grain yield over control.

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