INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 11, No. 5, p. 54-61, 2017

RESEARCH PAPER OPEN ACCESS

Impact of sorghum and mulberry water extract on narrow leaf weeds and yield of wheat

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Key words: Sorghum, Mulberry, Water extract, Wheat, *Phalaris minor*.

http://dx.doi.org/10.12692/ijb/11.5.54-61 Article published on November 12, 2017

Abstract

Wheat is the most important cereal crop in Pakistan and contributes 72% daily caloric intake with per capita wheat consumption of the region. Weeds pose serious problems in crop production as weed control is ignored due to lack of education and poor financial resources of the farmers. A field experiment was conducted to assess the allelopathic effect of mulberry and sorghum water extracts at different concentrations against noxious winter weeds like *Phalaris minor* and *Avenafatua*L. in wheat crop at the Agronomic Research Farm, University of Agriculture, Faisalabad, Pakistan. The experiment was conducted in randomized complete block design (RCBD) having four replications. All foliar treatments were applied after 30 days of sowing. Weedy check plot was kept for comparison and considered as a control. Mulberry water extract @ 36 L ha $^{-1}$ was effective regarding weed density of canary grass with 58% and 57% at 45 and 60 DAS respectively as compared to weedy check. Combine application of sorghum and mulberry extracts @ 18 L ha^{-1} of each was good to decrease weed growth and hence the fresh weight by 59-63% and dry weight too. Mulberry water extract @ 36 L ha $^{-1}$ was appeared better with 55% and 54% to control weed density of wild oat. Combine application of sorghum and mulberry extracts @ 18 L ha^{-1} of each produced higher number of productive tillers (343.75) per square meter and biological yield (13%) as compared to weedy check plot by discouraging the weed density and growth.

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Introduction

Wheat (*Triticumaestivum* L.) is one of the main agricultural crops in Pakistan, with 80 percent of farmers growing it on an area of around nine million hectares (close to 40 percent of the country's total cultivated land) during the winter or "Rabi" season. Wheat flour currently contributes 72 percent of Pakistan's daily caloric intake with per capita wheat consumption of around 124 kg per year, one of the highest in the world (USDA, 2017). Currently, about 65 percent of the wheat crop is used for food (FAO, 2013).

It is the most important cereal and also major staple food of Pakistan (Aslam *et al*., 2014; Blackshaw *et al*., 2016). In Pakistan, weeds pose serious problems in crop production as weed control is ignored due to lack of education and poor financial resources of the farmers. Hassan and Khan (2007) reported that wheat production was adversely affected by greater densities of *Avenafatua*L. by 20-30% and higher amount of seed rate was recommended to get the optimum yield of wheat when its fields were infested with *Avenafatua*L.Our farmer has come across with many useful and prominent ways and methods of dealing with these weeds which include chemical weed control and physical weed control methods. It is beyond any doubt that chemical weed control which is done through herbicides has proved effective in reducing weed biomass. Some weeds have developed herbicide resistance (Heap, 2008) and chemical herbicides usage has serious health concerns (Kudsk and Streibig, 2003) yet another problem arises which is related to these chemicals i.e. their degradation, residual effects in the soil, repeated use of a single compound that cause herbicide resistance in many weeds resulting in ineffective use of these herbicides and some of the herbicides have residual effect which is hazardous for soil micro flora. Mesotrione, a selective herbicide used for maize crop when applied to the soil, affect the population of soil microbes (Crouzet *et al*., 2010). Small farmers cannot afford the cost of weed management practices for crop production. Thus weeds growing among crop plants adversely affect yield and quality of the harvest and increase production costs, resulting in high economic losses. Some species of weed plants might be a serious threat to crop plants diversity, sharing nutrients, moisture, sun light and space (Ozturk *et al*., 2012). In Pakistan, weeds are accountable for 30 percent grain yield losses in wheat which amounts to Rs.1150 million annually (Marwat*et al*., 2008). Additionally, the risk of weed resistance development and high cost-benefit ratio are other disadvantages of herbicides (Kordali *et al*., 2009). Therefore, in recent years, a new approach such as plant allelopathic effects has been considered to suppress weeds in agricultural systems. Allelopathy is a natural, inexpensive, environmentally safe and an organic approach to control weeds and increase crop yields while conserving the ecosystem. The phenomenon of allelopathy can be practically utilized for weed control in the form of crop rotations, intercropping, allelopathic mulches, and spray of allelopathic plant water extracts (Bhowmik and Inderjit, 2003; Farooq *et al*., 2008; Jabran *et al*., 2010).

Allelopathic characteristics of many plant species including weeds, crops and trees need to be investigated for possible use in weed management programs. Blackshaw *et al*. (2006) observed that farmers are interested to explore more attractive and inclusive weed control strategies that minimize the serious weed infestation by time and in the use of low rate of synthetic herbicides with lower production costs. Allelopathic plants for example sorghum, sunflower and oats, contain a number of allelochemicals in low quality act as hormones and in high amount as herbicides. Allelopathic crop plants not only control weeds but also enhance crop growth and yield. Keeping in view the losses due to weeds, resistance creating to herbicides application and the recognized importance of allelochemicals in weed management, a present field experiment was conducted. The purpose of our study was to evaluate the role of sorghum and mulberry extracts for the control of weeds and above all, to provide our poor wheat grower a cheapest method of controlling weeds.

Materials and methods

Experimental site

A field study was carried out to evaluate different preparations as sorghum and mulberry extracts for their phytotoxic effects on weeds in wheat crop during the season 2014-2015 at Agronomic Research Area, University of Agriculture, Faisalabad, using randomized complete block design with four replications.

Crop husbandry

The wheat (Cultivar AARI-2011) was sown by hand drill in 22 cm apart row to row distance with gross plot measuring 7 m × 2.2 m with 10 rows in each plot. Sowing was done in well pulverized soil (soil type: Lyallpur soil series (Aridsol-fine silty, mined, hyperthermic, ustalfic, Haplagrid) in USDA classification). Fertilizers were applied according to the general recommendations of wheat (100-90-75 kg ha^{-1}). Irrigations were given according to the crop requirement. Treatments combination plan has been shown in Table 1.

Preparation of extracts and herbicidal solution

The allelopathic water extracts of sorghum and mulberry were prepared according to Cheema and Khaliq (2000). Recommended doses of iodosulforun + mesosulforun @ 14.4 g ha^{-1} a.i. (Atlantis3.6 WG); products of Bayer crop sciences, were used.

Application of treatments

There was no application of treatment in weedy check plot. It was left untreated throughout the crop growth period. Hand weeding was done twice at 30 and 45 days after sowing of crop. Iodosulfuran + Mesosulfuron (Atlantis 3.6WG) @ 14.4 g a.i. ha^{-1} were applied after 30 days of sowing. Similarly all other combinations of sorghum and mulberry water extracts were applied once in crop growth period after 30 days of sowing the wheat crop.

Weed parameters

Total number of plants of*Phalaris minor* and *Avenafatua* were counted separately present in 1 m^2 to measure the weed density. Fresh weight of individual weed was recorded by pulling out all of plants of particular specie and weighing them by ordinary scientific balance. After recording the fresh weight, weed samples were first sun dried, thereafter placed in an oven at 70°C for 72 hours till then all of the moisture was removed. These samples were weighed by ordinary balance to get dry weight.

Yield components

Total number of productive tillers was calculated by counting the number of productive tiller (tillers which bear grain) from an area of 1 m^2. Number of non-productive tillers was conducted by counting the number of non-productive tiller (tiller which do not bear grains or sterile tillers) from an area of 1 m^2. For the determination of biological yield, an area of 1 m^2 was harvested from each plot at fully mature stage. Total wheat biomass was measured by using a weighing balance.

Statistical analysis

Data collected regarding weed and yield parameters were analyzed statistically using Statistix 8.1 version, a computer package for statistical analysis and difference among treatments' means were compared by employing least significant difference (LSD) test at 5% probability level (Steel *et al.*, 1997).

Results and discussions

Weed parameters

Weed density has a great importance because it provides the index of weeds infestation in a particular field and its impact on economical yield of sole crop. In current study, densities, fresh and dry weights of canary grass (*Phalaris minor* L.) and wild oat (*Avenafatua*L.) were measured after 45 and 60 days of sowing to observe the effect of allelopathic chemicals.

Density, fresh and dry weights of canary grass

Canary grass infestation was significantly suppressed by application of sorghum and mulberry water extracts (Table 3). Combined application of sorghum and mulberry water extracts in different proportions was not effective.

Table 1. Treatment combinations.

No	Description
T_1	Weedy check (Control)
T_2	Hand weeding (30 and 45 DAS; days after sowing)
T_3	Iodosulfuran + Mesosulfuron (Atlantis 3.6WG) @14.4 g a.i. ha^{-1} (30 DAS)
T_4	Sorghum water extract 18 L ha^{-1} (30 DAS)
T_5	Sorghum water extract 27 L ha^{-1} (30 DAS)
T_6	Sorghum water extract 36 L ha^{-1} (30 DAS)
T_7	Mulberry water extract 18 L ha^{-1} (30 DAS)
T_8	Mulberry water extract 27 L ha^{-1} (30 DAS)
T_9	Mulberry water extract 36 L ha^{-1} (30 DAS)
T_{10}	Sorghum water extract 27 L ha^{-1} + Mulberry water extract 09 L ha^{-1} (30 DAS)
T_{11}	Sorghum water extract 18 L ha^{-1} + Mulberry water extract 18 L ha^{-1} (30 DAS)
T_{12}	Sorghum water extract 09 L ha^{-1} + Mulberry water extract 27 L ha^{-1} (30 DAS)

Total fresh and dry weights of canary grass were also significantly affected (Table 3) by the application of allelopathic extracts as compared to control. All of the treatments significantly reduced *Phalaris minor* fresh weight.These results are support by the findings of Jabran*et al.* (2010b) who reported that application of allelopathic extracts of sorghum and mulberry reduce the growth of *Phalaris minor*. These results also resembles with the findings of Haq*et al.* (2010) who said that mulberry water extract effectively control the narrow leave weeds. These findings relates to the previous observations of Jamil*etal.* (2009) who observed 27-53% decrease in weed density. Findings of Jabran*et al.* (2010b) are supporting the results that the application of allelopathic extracts of sorghum and mulberry reduced the growth of canary grass.

Table 2. Effect of sorghum and mulberry water extracts on yield parameters of wheat.

Treatments	Number of productive tillers m^{-2}	Number of non-productive tillers m^{-2}	Biological yield (ton ha^{-1})
Weedy check	305 g	26	12.67 g
Hand weeding	360 a	22	14.95 a
Iodosulfuran + Mesosulfuron	350 ab	24	14.60 b
SWE @ 18 L ha^{-1}	322 ef	25	13.19 f
SWE @ 27 L ha^{-1}	326 de	24	13.50 e
SWE @ 36 L ha^{-1}	335 cd	22	13.70 de
MWE @ 18 L ha^{-1}	314 fg	23	12.74 g
MWE @ 27 L ha^{-1}	319 ef	24	13.00 f
MWE @ 36 L ha^{-1}	330 de	22	13.51 e
SWE @ 27 L ha^{-1} + MWE @ 09 L ha^{-1}	338 cd	20	14.15 cd
SWE @ 18 L ha^{-1} + MWE @ 18 L ha^{-1}	343 bc	25	14.30 bc
SWE @ 09 L ha^{-1} + MWE @ 27 L ha^{-1}	336 cd	25	14 cd
LSD at 5% probability level	11.695	NS	0.2981

Different lettering shows the statistically significant difference among the performance of treatments (P< 0.05) DAS = Days after sowing; SWE = Sorghum water extract; MWE = Mulberry water extract; LSD = Least significant difference; NS = Non significant (statistically).

Density, fresh and dry weights of wild oat

Statistical analysis of data showed that sorghum and mulberry water extracts significantly inhibited wild oat infestation (Table 4). Weed density is of the major of causes which not only compete for nutrients but also compete for water and space and ultimately affect the biological and economical yields. Canary grass and wild oat are major rabi weeds in wheat field. They significantly suppressed biological yield of wheat. Fresh and dry weights showed the uptake and accumulation of mineral nutrients along with water consumption. In the current study fresh and dry weights of canary grass and wild oat were significantly reduced through application of allelopathic water extract. These results also resembles with the findings of Haq*et al.* (2010) who said that mulberry water extract effectively controlled the fresh and dry weights and growth of narrow leave weeds. These findings relates to the previous observations of Jamil*et al.* (2009). Jabran*et al.* (2008) reported that the application of allelopathic extracts of sorghum and mulberry reduce the growth of *Avenafatua*. Hamid *et al.* (2017) also reported that application of sorghum water extract in wheat field significantly affected weed density and growth.

Table 3. Effect of sorghum and mulberry water extracts on weed density, fresh and dry weights of canary grass in wheat crop.

Treatments	Weed density @45 DAS	Weed density @60 DAS	Fresh weight @45 DAS	Fresh weight @60 DAS	Dry weight @45 DAS	Dry weight @60 DAS
Weedy check	18.50 a	19.25 a	8.75 a	12.25 a	3.04 a	3.75 a
Hand weeding	0.00 j	0.00 i	0.00 f	0.00 h	0.00 g	0.00 h
Iodosulfuran + Mesosulfuron	5.00 i	4.50 h	2.00 e	3.75 g	1.19 f	1.44 g
SWE @ 18 L ha^{-1}	16.25 b	16.25 b	5.25 bc	9.50 b	2.52 b	3.03 b
SWE @ 27 L ha^{-1}	14.50 c	14.50 bc	5.50 b	8.50 bc	2.42 b	2.85 bc
SWE @ 36 L ha^{-1}	13.25 cd	3.25 cd	4.50 bcd	7.25 cd	2.39 b	2.16 efg
MWE @ 18 L ha^{-1}	12.50 de	13.25 cd	4.75 bcd	9.50 b	2.03 c	2.48 cd
MWE @ 27 L ha^{-1}	9.00 gh	9.00 fg	4.50 bcd	8.00 bc	1.80 d	2.16 de
MWE @ 36 L ha^{-1}	7.75 h	8.25 g	4.00 bcd	6.25 de	1.59 de	1.86 ef
SWE @ 27 L ha^{-1} + MWE @ 09 L ha^{-1}	11.50 ef	12.00 de	3.50 cde	5.75 def	1.57 e	1.86 ef
SWE @ 18 L ha^{-1} + MWE @ 18 L ha^{-1}	10.25 fg	10.75 ef	3.25 de	5.00 ef	1.53 e	1.58 fg
SWE @ 09 L ha^{-1} + MWE @ 27 L ha^{-1}	10.50 fg	11.00 e	3.75 bcde	5.50 ef	1.69 de	2.03 e
LSD at 5% probability level	1.5404	1.7530	1.7623	1.5974	0.2205	0.4086

Different lettering shows the statistically significant difference among the performance of treatments ($P< 0.05$) DAS = Days after sowing; SWE = Sorghum water extract; MWE = Mulberry water extract; LSD = Least significant difference.

Yield parameters of wheat

Most of the treatments significantly influenced the productive tillers as compared to control except MWE @ 18 L ha^{-1} (Table 2). Biological yield means the yield of total biomass of the crops including straw and grains.It reflects the efficiency of nutrient uptake, water consumption and synthesis of macro and micro molecules. Total number of productive tillers is a main attribute which determines the biological and economical yield and net returns. Application of allelopathic extracts of sorghum and mulberry significantly affected the productive tiller and ultimately biological yield. The increase in productive tillers was possibly due to weeds suppressing ability of sorghum and mulberry water extracts and efficient utilization of resources by the wheat crop. These findings are supported by the work reported by Einhelling and Rasmussen (1989) who said that sorghum water extract have strong weed suppressive potential and ultimately enhanced the wheat growth. Increase in biological yield of wheat may be due to the weed suppressing ability of sorghum and mulberry water extracts that result in less competition among crop and weed plants and ultimately the more growth. These results also resembles with the findings of Haq*et al.* (2010) who said that mulberry water extract effectively control the weeds population and improved the biological yield of wheat. Hamid *et al.* (2017) reported that application of sorghum water extract in wheat field significantly affected weed density, productive tillers, non-productive tillers, thousand grain weight, biological yield and grain yield. Herbicide sprayed plots produced minimum number of weeds, maximum productive tillers m^{-2}, thousand grain weight biological yield and grain yield as compared to control.

The increase in yield is attributed to more tillers per unit area and luxurious vegetative growth. More biological yield in case of herbicide application and in plots with sorghum and mulberry water extracts applied @ 18 L ha^{-1} may be due to the fact that decrease in weeds population due to herbicide application and sorghum and mulberry water extracts applied at equal concentration resulted in stimulation of vegetative growth of wheat which enhanced water and nutrient use efficiency by accumulating more nutrient and increasing the plant height and more vigorous growth.

Table 4. Effect of sorghum and mulberry water extracts on weed density, fresh and dry weights of wild oat in wheat crop.

Treatments	Weed density @45 DAS	Weed density @60 DAS	Fresh weight @45 DAS	Fresh weight @60 DAS	Dry weight @45 DAS	Dry weight @60 DAS
Weedy check	16.25 a	15.50 a	22.22 a	36.45 a	2.84 a	4.26 a
Hand weeding	0.00 g	0.00 h	0.00 g	0.00 g	0.00 f	0.00 g
Iodosulfuran + Mesosulfuron	4.25 f	4.50 g	8.69 f	11.80 f	1.02 e	1.43 f
SWE @ 18 L ha^{-1}	13.75 b	13.00 b	18.43 b	30.32 b	2.31 b	3.58 b
SWE @ 27 L ha^{-1}	12.50 bc	11.50 bc	17.74 b	29.29 b	2.14 b	3.46 b
SWE @ 36 L ha^{-1}	12.00 c	9.00 de	17.48 b	28.85 b	2.12 b	3.42 b
MWE @ 18 L ha^{-1}	9.50 d	8.00 ef	14.88 c	24.44 c	1.71 c	2.87 c
MWE @ 27 L ha^{-1}	8.25 de	8.75 def	13.17 d	21.87 cd	1.59 cd	2.53 cd
MWE @ 36 L ha^{-1}	7.25 e	7.00 f	11.65 de	19.22 de	1.41 d	2.38 d
SWE @ 27 L ha^{-1} + MWE @09 L ha^{-1}	11.25 c	12.00 bc	11.51 e	19.24 de	1.53 cd	2.23 de
SWE @ 18 L ha^{-1} + MWE @ 18 L ha^{-1}	9.25 d	9.25 de	11.18 e	18.03 e	1.36 d	1.88 ef
SWE @ 09 L ha^{-1} + MWE @ 27 L ha^{-1}	8.50 de	10.50 cd	12.37 de	20.47 de	1.47 cd	2.45 cd
LSD at 5% probability level	1.4060	1.7767	1.6283	3.5653	0.2959	0.4670

Different lettering shows the statistically significant difference among the performance of treatments ($P< 0.05$)
DAS = Days after sowing; SWE = Sorghum water extract; MWE = Mulberry water extract; LSD = Least significant difference.

Conclusion

It is concluded that among all weed control treatments, herbicides showed best results but the allelopathic effects of combine application of sorghum and mulberry water extracts were also prominent and followed the herbicides.

In case of sorghum and mulberry concentrations, application of 18 L ha^{-1} of each at 30 DAS resulted in maximum biological yield and net returns. Sorghum and mulberry water extract affect weeds and wheat growth due to either inhibitory or stimulatory effects depending upon the quantity of sorghum and stage of growth of wheat. The use of farm grown sorghum for weed control is less costly, farmers' friendly and organic method of weed control that can be explored as cheap method for increasing wheat yield in weedy fields. So the allelopathic potential of sorghum and mulberry and their effects on weed flora should be further explored as less expensive, safe and harmless method of weeds control in wheat crop.

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