WILD OAT (*AVENA FATUA* L.) AND CANARY GRASS (*PHALARIS MINOR* RITZ.) MANAGEMENT THROUGH ALLELOPATHY

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Abstract: Environmental contamination, herbicide resistance development among weeds and health concerns due to over and misuse of synthetic herbicides has led the researchers to focus on alternative weed management strategies. Allelochemicals extracted from various plant species can act as natural weed inhibitors. In this study, allelopathic extracts from four plant species sorghum [*Sorghum bicolor* (L.) Moench], mulberry (*Morus alba* L.), barnyard grass [*Echinochloa crusgalli* (L.) Beauv.], winter cherry [*Withania somnifera* (L.)] were tested for their potential to inhibit the most problematic wheat (*Triticum aestivum* L.) weeds wild oat (*Avena fatua* L.) and canary grass (*Phalaris minor* Ritz.). Data regarding time to start germination, time to 50% germination, mean germination time, final germination percentage, germination energy, root and shoot length, number of roots, number of leaves, and seedling fresh and dry weight was recorded for both the weeds, which showed that mulberry was the most inhibitory plant species while sorghum showed least allelopathic suppression against wild oat. Mulberry extracts resulted in a complete inhibition of the wild oat germination. The allelopathic potential for different plants against wild oat was in the order: mulberry > winter cherry > barnyard grass > sorghum. Mulberry, barnyard grass and winter cherry extracts resulted in a complete inhibition of canary grass. Sorghum however exhibited least suppressive or in some cases stimulatory effects on canary grass. Plants revealing strong allelopathic potential can be utilized to derive natural herbicides for weed control.

Key words: allelopathy, canary grass, wild oat, weed control

INTRODUCTION

Wild oat (*Avena fatua* L.) and canary grass (*Phalaris minor* Ritz.) being the most troublesome grassy weeds in wheat (*Triticum aestivum* L.) result in yield reduction by about 30% (Bell and Nalewaja 1968; Malik and Singh 1995; Hobbs *et al.* 1998). These weeds not only cause yield reduction but also deteriorate the produce quality by seed mixing with grains and interfere the harvest operations. Although herbicides available in the market may offer effective control of these weeds but environmental damages occur (Zhu and Li 2002); herbicide resistance development among weeds (Heap 2008) and health concerns due to over and misuse of synthetic herbicides (Kudsk and Streibig 2003) has led the researchers to focus on alternative weed management strategies (Jabran *et al.* 2008). Allelopathy is the process in which secondary metabolites produced by plants, micro-organisms, viruses and fungi influence the growth and development of agricultural and biological systems (excluding animals), this may be stimulatory or inhibitory (Torres *et al.* 1996). Allelopathic potential of sorghum [*Sorghum bicolor* (L.) Moench] has been intensively studied (Hejl and Koster 2004; Jabran *et al.* 2008), nevertheless very little information is available regarding the allelopathic potential of mulberry (*Morus alba* L.), barnyard grass [*Echionoachloa crusgalli* (L.) Beauv.] and winter cherry (*Withania somnifera* L.). These species may act as a potential source of allelochemicals for natural weeds control.

In the present study we used four allelopathic plant species including sorghum, mulberry, barnyard grass and winter cherry to investigate their phytotoxic effects if any, on the noxious weeds of wheat viz. wild oat and canary grass.

MATERIALS AND METHODS

Plant materials

Seeds of the weed species canary grass (*P. minor*) and wild oat (*A. fatua*) were obtained from Ayub Agriculture Research Institute Faisalabad. Pakistan. Leaves of sorghum (*S. bicolor* cv. 85 G 83) and mulberry (*M. alba*) and leaves and stems of barnyard grass (*E. crusgalli*) and winter cherry (*W. somnifera*) were collected from the Agronomic Research Area University of Agriculture Fais-

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alabad, Pakistan. The plant materials were first dried in shade and then kept in oven at 70°C until constant weight. The plant material was then ground to fine flour using electric grinder.

Preparation of water extracts

Respective grinded plant parts were weighed using electric balance and then well mixed in distilled water with 1 : 10 (w/w) ratio and soaked for 24 h at room temperature, the mixture was then filtered using Whatman No. 42 filter paper to be used fresh in the bioassay (Farooq *et al.* 2008).

Germination tests/bioassay

Seeds (10 in each replication) of the two weed species were placed in Petri dishes (60x15 mm) between layers of moist Whatman 45 filter paper at 27°C in an incubator. Ten ml of respective allelopathic water extract (WE) was added for each plant species, while in the control distilled water was added. The experiment was laid out in completely randomized design with four replications. Germination was observed daily according to the seedling evaluation Handbook of Association of Official Seed Analysts (AOSA 1990). The time to get 50% germination (T_{50}) was calculated according to the following formulae of Coolbear *et al.* (1984) modified by Farooq *et al.* (2005):

$$T_{50} = t_i \frac{\left(\frac{N}{2} - n_i\right)\left(t_j - t_i\right)}{n_j - n_i}$$

where N is the final number of germinated seeds and n_i, n_j cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts (1981):

$$MGT = \frac{\sum Dn}{n}$$

where n is the number of seeds, which were germinated on day D, and D is the number of days counted from the beginning of germination.

Energy of germination was recorded at 4th day after planting. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested (Farooq *et al.* 2005).

Radicle and plumule lengths and seedling fresh and dry weights were recorded 15 days after sowing. Number of leaves at harvest were designated as leaf score (Farooq *et al.* 2007).

Statistical analysis

Graphical presentation of data was carried out using Microsoft Excel program. For comparison of treatment means, standard errors were computed using Microsoft Excel program.

RESULTS AND DISCUSSION

None of the wild oat seeds could germinate upon the application of mulberry water extract (Table 1). All other treatments reduced the time to start germination, time to 50% germination (T_{50}), mean germination time (MGT) compared with control, minimum being for the winter cherry treatment (Table 1). Wild oat treatment with sorghum and barnyard grass water extracts improved the final germination percentage (GP) and germination energy (GE) compared with control, nonetheless minimum for

Table 1. Effect of the of sorghum, mulberry, barnyard grass and winter cherry water extracts application on germination of wild oat and canary grass

	Control	Sorghum	Mulberry	Barnyard grass	Winter cherry	LSD
Wild oat						
A	4.33 a[1]	4.00 a	0.00 c	4.00 a	1.33 b	1.063
B	4.33 a	3.75 a	0.00 c	3.75 a	1.33 b	1.218
C	5.33 a	4.54 a	0.00 c	4.39 a	1.92 b	1.206
D	23.37 b	36.67 a	0.00 d	40.0 a	13.33 c	9.219
E	10.0 b	30.0 a	0.00 b	26.67 a	3.33 b	10.18
Canary grass						
A	4.67 a	4.0 a	0.00 b	0.00 b	0.00 b	0.973
B	4.92 a	3.83 b	0.00 c	0.00 c	0.00 c	0.375
C	6.21 a	5.53 b	0.00 c	0.00 c	0.00 c	0.518
D	43.33 a	50.0 a	0.00 b	0.00 b	0.00 b	9.707
E	16.67 b	30.0 a	0.00 c	0.00 c	0.00 c	4.854

[1]two means not sharing a letter in common in each row differ significantly at $p \leq 0.01$

A time to start germination [days]
B time taken for 50 % germination [days]
C mean germination time [days]
D final germination [%]
E germination energy [%]

Table 2. Effect of the of sorghum, mulberry, barnyard grass and winter cherry water extracts application on seedling growth of wild oat and canary grass

	Control	Sorghum	Mulberry	Barnyard grass	Winter cherry	LSD
Wild oat						
F	11.59 a[1]	11.31 a	0.00 c	5.48 b	0.79 c	2.284
G	17.50 ab	18.55 a	0.00 c	14.83 b	2.79 c	2.981
H	3.28 a	3.11 a	0.00 b	3.72 a	0.33 b	0.713
I	1.28 b	1.67 a	0.00 d	1.22 b	0.33 c	0.265
J	0.13 a	0.11 a	0.00 b	0.14 a	0.01 b	0.037
K	0.021 a	0.024 a	0.00 c	0.016 b	0.001 c	0.003
Canary grass						
F	3.36 b	5.53 a	0.00 c	0.00 c	0.00 c	1.345
G	7.24 b	10.25 a	0.00 c	0.00 c	0.00 c	0.965
H	1.00 b	1.22 a	0.00 c	0.00 c	0.00 c	0.065
I	1.0 a	1.0 a	0.00 b	0.00 b	0.00 b	0.004
J	0.056 b	0.036 a	0.00 c	0.00 c	0.00 c	0.003
K	0.0154 a	0.0085 b	0.00 c	0.00 c	0.00 c	0.003

[1]two means not sharing a letter in common in each row differ significantly at $p \leq 0.01$

F – radicle length [cm]
G – plumule length [cm]
H – root score
I – leaf score
J – seedling fresh weight [g]
K – seedling dry weight [g]

wild oat GP and GE was not from winter cherry treatment (Table 1). Data regarding the seedling traits revealed that maximum radicle length was noted for the control, this was similar to that of sorghum extract application (Table 2). Maximum plumule length was observed in wild oat treated with sorghum extract, which was similar to the control (Table 2). Nonetheless minimum radicle and plumule lengths were recorded from the application of winter cherry (Table 2). Maximum root score was recorded in wild oat seeds treated with barnyard grass extract followed by control and sorghum extract treatments (Table 2). Maximum leaf score was noted in wild oat seeds treated with sorghum extract followed by barnyard grass extract and control (Table 2). Whereas minimum root and leaf scores were recorded in wild oat seeds treated with winter cherry extract (Table 2). Likewise, maximum seedling fresh weight was recorded for the wild oat seedlings raised with barnyard extract followed by control sorghum extract application (Table 2). Minimum dry weight was recorded for sorghum extract treatment followed by control (Table 2). Nonetheless minim wild oat fresh and dry weights were noted for the application of winter cherry extract (Table 2).

In canary grass, none of the seeds could germinate by the application of mulberry, barnyard grass and winter cherry extracts (Table 1). Nonetheless application of sorghum water extracts reduced the time to start germination, T_{50} and MGT while increased final germination percentage, germination energy, radicle and plumule lengths, and root and leaf scores (Table 1, 2). Nevertheless, canary grass seedling fresh and dry weights were reduced by the application of sorghum extract (Table 2).

Application of mulberry extract to both wild oat and canary grass seeds resulted in complete germination inhibition of both weeds, which can be attributed to strong allelopathic potential of the mulberry plant. Allelopathic potential of the mulberry has also been explored previously by Mughal (2000) and Hong *et al.* (2003) on pulses and radish, respectively. Mughal (2000) evaluated inhibitory effects of mulberry leaf extract on pulses including peas, broad beans and lentils and reported suppression of germination and seedling growth. Nonetheless no other study demonstrated the allelopathic potential of mulberry for suppression of other plant species, in particular weeds. The findings of this study provide basis for investigating the allelopathic potential of mulberry and its use for natural weed inhibition.

Application of winter cherry extract also resulted in a complete inhibition of canary grass and was effective to suppress wild oat growth by impairing its germination potential and seedling growth. Interestingly, the wild oat seeds treated with winter cherry extract germinated earlier than the ones treated with distilled water (control), the reasons of which needs to be explored.

Canary grass germination was completely inhibited by barnyard grass extract. Although final germination percentage was more where wild oat seeds were treated with barnyard grass extract, it inhibited the weed growth by decreasing radical and plumule length. Root score was, however, improved by the BE for wild oat that may be due to the presence of some growth promoting substances.

Only slight inhibition in wild oat germination was recorded for the application of sorghum extract, nevertheless it promoted some seedling growth characteristics. Sorghum extract did not inhibit the germination in canary grass, rather it promoted the germination by decreasing the time to start germination, T_{50}, MGT, and improving the final germination percentage (Table 1). The growth of canary grass was also promoted by sorghum extract treatment in terms of improved radicle and plumule lengths, and root score (Table 2). Sorghum has been intensively reported to posses strong allelopathic potential and obstruct the growth processes of other plant species (Hejl and Koster 2004; Jabran *et al.* 2008), however, sorghum cultivars vary for their allelopathic potential (Alsaadawi *et al.* 1986; Alsaadawi *et al.* 2005) and this might be a possible reason that sorghum did faintly affect the growth of weed species in this study.

Winter cherry has already been used in the manufacturing of human medicine but its allelopathic potential is being reported for the first time. It may be possible in future to derive herbicides from this plant for natural weed inhibition.

In conclusion, the allelopathic extracts of winter cherry and mulberry strongly inhibited the germination and seedling growth of the test species. Hence, the allelochemicals extracted from winter cherry and mulberry can be employed for the natural control of *Avena fatua* and *Phalaris minor,* thus achieving the aim of environmental safety.

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POLISH SUMMARY

ZWALCZANIE *AVENA FATUA* L. I *PHALARIS MINOR* RITZ. PRZY WYKORZYSTANIU ALLELOPATII

Skażenie środowiska, rozwój odporności na herbicydy wśród chwastów i przesłanki zdrowotne związane z nieprawidłowym używaniem herbicydów skłoniły badaczy do skoncentrowania się na alternatywnych strategiach zwalczania. Allelochemikalia uzyskane z różnych gatunków roślin mogą działać tak jak naturalne związki inhibujace chwasty. W przedstawionych badaniach testowano zdolność allelopatycznych wyciągów z czterech gatunków roślin sorgo, (*Sorghum bicolor* L., *Echinochloa crus-galli* (L.) Beauv., *Withania somnifera* L.), w celu określenia ich potencjału inhibicyjnego przeciwko stwarzającym problemy w pszenicy (*Triticum aestivum* L.) chwastom, mianowicie: *Avena fatua* L., *Phalaris minor* Ritz. Dane dotyczące czasu obejmującego okres przed początkiem kiełkowania, procent kiełkowania, czas potrzebny do skiełkowania 50% nasion, średni czas kiełkowania, końcowy czas kiełkowania, energię kiełkowania, długość korzeni i pędu, liczbę korzeni i liści, świeżą oraz suchą masę roślin, określono dla obydwóch gatunków chwastów, co wykazało, że morwa była najbardziej inhibującą rośliną, a sorgo wykazało najniższy stopień allelopatycznej supresji przeciwko *A. fatua.* Wyciągi z morwy powodowały całkowitą inhibicję kiełkowania *A. fatua.* Allelopatyczny potencjał różnych roślin przeciwko *A. fatua* był następujący: morwa > *W. somnifera* > *E. crus-galli* > sorgo. Jednak sorgo wykazało najmiej ograniczający albo w niektórych przypadkach stymulujący efekt na *P. minor.* Rośliny z silnym alelopatycznym potencjałem mogą być użyte do uzyskania naturalnych herbicydów zwalczających chwasty.