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Full Length Research Paper

Exploring fungal-derived compounds for weed management: A focus on *Phalaris minor*

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In the present study, herbicidal activity of metabolites of four fungi namely *Drechslera hawaiiensis* M.B. Ellis, *D. biseptata* (Sacc. and Roum.) Richardson and Fraser, *D. holmii* (Luttr.) Subramanian and Jain, and *D. australiensis* (Bugnicourt) Subramanian and Jain., was evaluated against *Phalaris minor* Retz., a problematic monocotyledonous weed of wheat. Fungal metabolites were prepared by incubating the fungal species in M-1-D medium for 28 days at 25°C. In laboratory bioassays, the effect of original (100%) and diluted (50%) fungal metabolites was studied on germination and seedling growth of the target weed species. All the four fungal metabolites significantly reduced seed germination, and shoot and root growth of seedlings of the test weed species. The highest activity against seed germination was exhibited by metabolites of *D. australiensis* resulting in up to 94% reduction in the studied parameter. Similarly the best herbicidal activity against shoot growth was due to metabolites of *D. hawaiiensis* where 65% and 64% reduction in length and dry biomass of shoot was recorded. In foliar spray pot bioassays, fungal metabolites were sprayed on 1-week and 2-week old weed plants four times with 4 days intervals. In general, the effect of the fungal metabolites on various shoot and root growth parameters was insignificant. The present study concludes that metabolites of *D. australiensis* can be used as potent pre-emergence herbicides for the management of *P. minor.*

Keywords: Alternative herbicides, fungal metabolites, littleseed canarygrass, *Phalaris minor*, weed of wheat.

INTRODUCTION

Wheat is an important staple food crop of Pakistan. The yield of wheat in Pakistan is severely affected by weeds (Siddiqui et al., 2010). There have been reported more than 40 weed species from various wheat growing areas of Pakistan (Siddiqui and Bajwa, 2001; Qureshi and Bhatti, 2001). Weeds compete with the crop plants not only by occupying the space (Wright et al., 2001) but also compete for other resources such as water (Thakur, 1984), light and nutrients (Tollennaar et al., 1997). In addition, inhibitory effects of weeds on crop plants through the release of allelochemicals are also well documented (Javaid et al., 2007).

Littleseed canarygrass (*Phalaris minor* Retz.) is one of the most problematic, frequently occurring and densely populated weed. It is a narrow-leaf highly competitive weed that caused 33–68% reduction in yield in different wheat varieties in Pakistan when there is 1:1 ratio of wheat and weed (Siddiqui et al., 2010). Depending upon the density of this weed, other workers have reported 10– 65% yield losses in wheat (Mehra and Gill, 1988; Chhokar et al., 2008). It is also a troublesome weed of wheat fields in India, USA, Canada, Africa, Australia, France, Iran, Iraq and Mexico (Holm et al., 1979). Due to introduction of high-yielding dwarf wheat varieties along with increased irrigation and fertilizer facilities, *P. minor* has became aggravated pest. In addition, rice–wheat crop rotation also stimulated its emergence, growth and development (Balyan and Malik, 1989; Chhokar and Malik, 1999; Chhokar et al., 1999; Singh et al., 1995, 1999).

Although synthetic herbicides are very effective in controlling weeds of wheat (Cheema et al., 2006; Bibi et al., 2008), however, the use of these agro-chemicals has increased consumer's concern due to environmental pollution and other health related issues (Marin et al.,

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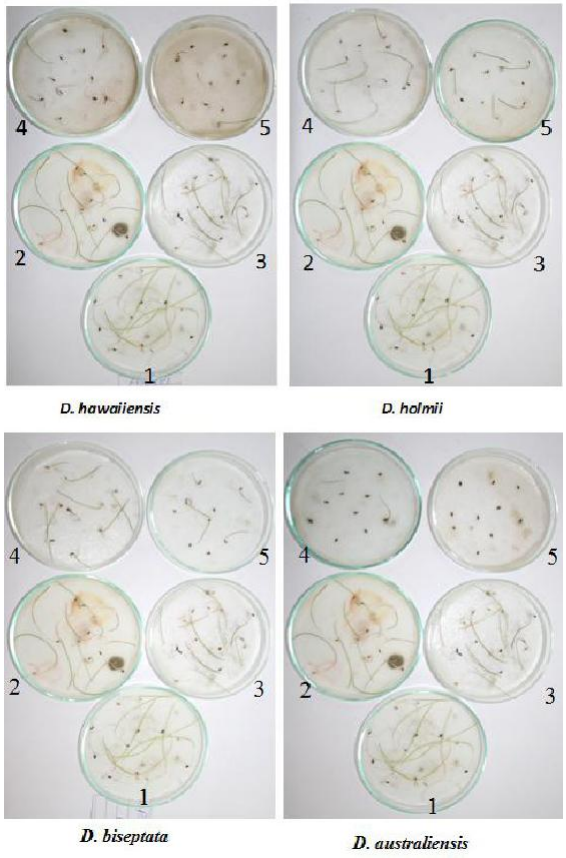

Figure 1. Effect of culture filtrates of four *Drechslera* species on germination and growth of *Phalaris minor* in laboratory bioassays. 1: Control (water), 2: 50% Medium, 3: 100% Medium, 4: 50% Fungal culture filtrates (FCF), 5: 100% FCF.

2003; Rial-Otero et al., 2005), as well as numerous cases of herbicide resistance in many weeds world over (Devine and Shukla, 2000; Yuan et al., 2007). For more sustainable systems, there is an increasing trend towards the search for alternatives of these chemicals which are based on natural compounds (Cuthbertson and Murchie, 2005). Use of fungal metabolites with herbicidal activity is one of the alternative strategies to manage the weeds (Palmer et al., 2005; Javaid and Adrees, 2009; Javaid and Ali, 2011). The present study was carried out to investigate the herbicidal activity of metabolites of various *Drechslera* species for the management of *P. minor.*

MATERIALS AND METHODS

Preparation of fungal culture filtrates

Cultures of four fungal species *Drechslera hawaiiensis* M.B. Ellis, *D. biseptata* (Sacc. and Roum.) Richardson and Fraser, *D. holmii* (Luttr.) Subramanian and Jain, and *D. australiensis* (Bugnicourt) Subramanian and Jain were obtained from Fungal Culture Bank of Pakistan, Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan. Minimal medium (M-1-D) was prepared in distilled water as described by Evidente et al. (2006). This medium consisted of 0.79 mM KNO_3, 1.2 mM $Ca(NO_3)_2$, 3.0 mM $MgSO_4$, 0.87 mM KCl, 87.6 mM sucrose, 0.14 mM NaH_2PO_4, 22 µM H_3BO_3, 7.4 µM $FeC1_3$, 27.1 mM ammonium tartrate, 8.7 µM $ZnSO_4$, 30 µM $MnSO_4$, and 4.5 µM KI. HCl (0.1 M) was used to maintain pH at 5.5. This medium was poured into 500 mL flasks at the rate of 200 mL medium in each flask. Flasks were autoclaved at 121°C for 20 min. After cooling at room temperature, flasks were inoculated with 5 mm discs of each of the four test fungal species and incubated at 25±2 ºC in an incubator for 28 days. Cultures were filtered through four layers of muslin cloth and centrifuged at 4000 rpm for ten minutes. These filtrates were filtered through sterilized Whatman filter paper No. 1. and stored at 4ºC in a refrigerator. Dilutions (50%) of these original (100%) filtrates were prepared by adding autoclaved distilled water following Javaid and Adrees (2009). Filtrates were generally used within a week to avoid any contamination or alteration.

Laboratory bioassays

Seeds of *P. minor* were collected during May 2009 from wheat fields of University of the Punjab, Lahore, Pakistan. Experiment was conducted in November 2009. Weed seeds were surface sterilized with 1% sodium hypochlorite for 10 min followed by numerous washings with autoclaved water. Twenty seeds of the test weed species were arranged at equal distance in sterilized 9 cm diameter Petri plates lined with sterilized filter papers. Three milliliters of original as well as diluted fungal metabolites of each test species were poured in the Petri plates. Original and diluted M-1-D medium was used as positive control and distilled water as negative control. Each treatment was replicated four times. Completely randomized design (CRD) was followed in a growth room maintained at 16°C with 10 h light period daily. Data regarding germination of seeds was recorded after 15 days. Plants were thinned and 10 uniform seedlings were selected for measurement of different root and shoot growth parameters (Figure 1). Materials were dried at 60°C in an electrical oven till constant weight (Javaid and Ali, 2011).

Foliar spray bioassays

Pot experiment was conducted during November-December 2009 in University of the Punjab, Lahore, Pakistan. Plastic pots of 8-cm diameter and 12-cm deep were filled with sandy loam soil (450 g) having organic matter 0.69%. Initially ten weed seeds were sown in each pot and thinned to six uniform seedlings after germination. For the performance of foliar spray, pots were arranged in two sets, 1-week and 2-week old seedlings. Each treatment was replicated four times. All the pots were set in a completely randomized design under natural environmental conditions of light, humidity and temperature. Original metabolites of the four fungal species were sprayed on 1-week and 2-week old weeds plantlets. Both the sets were sprayed 4 times with 4 days intervals in between. Negative control treatment was sprayed with distilled water whereas M-1-D medium without fungal inoculation was used as positive control. Sprays were conducted during evening hours. Plants were uprooted after 50 days of sowing. Data regarding various shoot and root growth parameters were recorded (Javaid et al., 2011).

Statistical analysis

Analysis of variance followed by Duncan's Multiple Range Test

Table 1. Effect of culture filtrates of four *Drechslera* species on germination and growth of *Phalaris minor* in laboratory bioassays.

Fungal species	Conc. (%)	Germination (%)	Shoot length (mm)	Shoot fresh wt. (mg)	Shoot dry wt. (mg)	Root length (mm)	Root fresh wt. (mg)	Root dry wt. (mg)
Control	0	100 a	52 a	5.17 a	0.53 a	58 a	5.31 a	0.78 a
Growth medium	50	96 a	44 b	4.70 ab	0.45 b	44 b	4.31 b	0.63 b
	100	96 a	42 b	4.35 b	0.41 bc	37 c	3.72 c	0.53 c
D. hawaiiensis	50	81 c	26 e	2.65 d	0.27 d	25 d	2.27 d	0.35 d
	100	56 e	18 h	1.90 e	0.19 e	10 f	0.88 g	0.18 f
D. holmii	50	88 b	29 d	3.45 c	0.39 c	19 e	1.90 de	0.35 d
	100	56 e	25 ef	2.62 d	0.29 d	11 f	0.96 g	0.19 f
D. biseptata	50	77 c	35 c	3.05 cd	0.38 c	12 f	1.40 f	0.28 e
	100	65 d	23 fg	2.62 d	0.29 d	11 f	0.86 g	0.17 f
D. australiensis	50	13 f	21 g	3.62 c	0.37 c	16 e	1.50 ef	0.34 d
	100	6 g	21 g	2.75 d	0.29 d	6 g	0.65 g	0.15 f

In a column, values with different letters show significant difference (P≤0.05) as determined by Duncan's Multiple Range Test.
Note: 100% means original fungal culture filtrates.

(Steel and Torrie, 1980) was utilized to analyze different growth parameters.

RESULTS AND DISCUSSION

Laboratory bioassays

Data regarding the effect of metabolites of the four *Drechslera* spp. against germination of *P. minor* seeds is presented in Table 1 and Figure 1. The effect of both 100% as well as 50% of M-1-D medium was insignificant (*P*≤0.05) on seed germination. Both original as well as diluted metabolites of all the four test fungal species significantly reduced germination by 12-94%. Adverse effect of the original metabolites on germination was more pronounced as compared to the diluted ones. Metabolites of *D. australiensis* were found the most effective where 87% and 94% suppression in seed germination was recorded due to diluted and original metabolites, respectively. Recently, Akbar and Javaid (2010) reported that metabolites of *D. australiensis* prepared in malt extract medium were also effective against germination of *P. minor*. In the present study, fungal metabolites prepared in M-1-D medium exhibited greater herbicidal activity than those prepared in malt extract medium by Akbar and Javaid, (2010). The results of these studies clearly indicate that type of growth medium also has an effect on herbicidal potential of fungal culture filtrates.

Shoot length of seedlings was significantly reduced by metabolites of all the four test fungal species. Although shoot length was also significantly reduced in original and diluted growth medium treatments, however, the effect was not as much pronounced as in case of fungal metabolites. In contrast to the fungal metabolites where 33–63% reduction in shoot length was recorded over control, there was only 15–19% reduction in shoot length due to growth medium. Moreover, it is likely that most of the ingredients present in growth medium were utilized during the fungal growth, and hence these ingredients could have very little effect in fungal metabolites as compared to pure growth medium. Metabolites of *D. hawaiiensis* were found to be the most effective in suppressing the shoot length followed by metabolites of *D. australiensis* (Table 1). The effect of growth medium and fungal metabolites on fresh and dry biomass of shoot was generally similar to that of their effect on shoot length. All the fungal metabolites significantly reduced the fresh and dry biomass of shoot by 30–63% and 24–64% over control, respectively (Table 1). Findings of the present study are in agreement with the results of earlier studies reporting that the culture filtrates of other *Drechslera* species exhibit herbicidal activity (Evidente et al., 2006; Javaid and Adrees, 2009; Javaid et al., 2011). Drazepinone, a trisubstituted tetrahydronaphthofuroazepinone with herbicidal activity against monocot weeds have been reported from *D. siccans* (Evidente et al., 2005). Similarly**,** Sugawara et al (1987) isolated an herbicidal compound ophiobolin I from *D. sorghicola* and *D. maydis*.

Pure growth medium adversely and significantly reduced length as well as fresh and dry biomass of the seedlings. However, the effect was not as much pronounced as that of fungal metabolites. Metabolites of

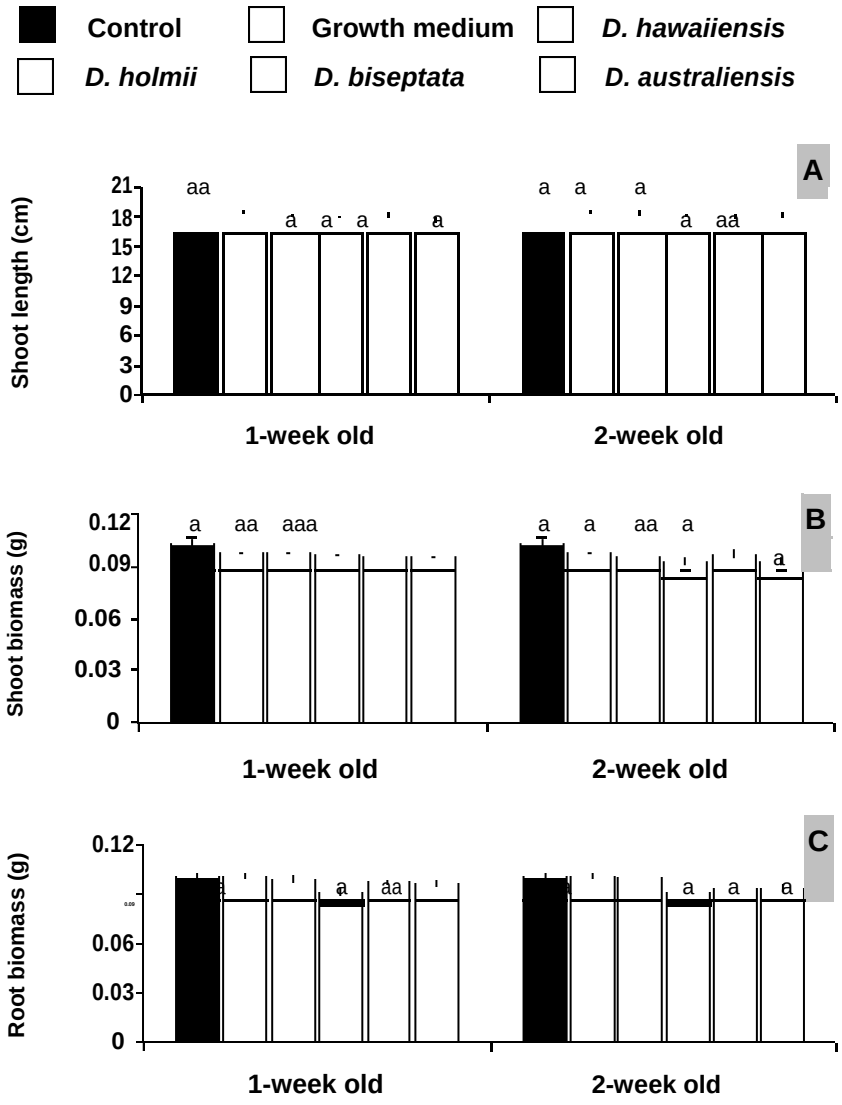

Figure 2. Effect of foliar spray of culture filtrates of four species of *Drechslera* on growth of 1-week and 2-week old *Phalaris minor* plants. Vertical bars show standard errors of means of four replicates. Values with different letters show significant difference as determined by Duncan's Multiple Range Test at P≤0.05.

all the four test fungal species significantly reduced length as well as fresh and dry biomass of root as compared to control and growth medium treatments. There was 56–89% reduction in root length due to different concentrations of the various culture filtrates as compared to control. Similarly, different fungal metabolite treatments reduced fresh and dry biomass of root by 57–88% and 55–81% over control. The highest adverse effect on root growth was exhibited by metabolites of *D. australiensis* followed by metabolites of *D. hawaiiensis* (Table 1).

Pot trials

Data regarding the effect of foliar spray of various fungal metabolites on shoot length, and shoot and root biomass of *P. minor* is presented in Figure 2. The effect of various foliar spray treatments was insignificant both on 1-week and 2-week old *P. minor* plants. The non-significant effect of the fungal metabolites on pot grown *P. minor* plants could be attributed to the very small quantities of the herbicidal constituents present in these metabolites. The results of the laboratory bioassays clearly indicate that the herbicidal constituents present in these fungal culture filtrates are highly effective against very young and delicate seedlings. It is likely that if these metabolites are used in concentrated form, these may be effective against pot grown *P. minor* plants. Moreover, laboratory bioassays also revealed that metabolites of *D. australiensis* can suppress germination of *P. minor* seeds up to 94%. These metabolites can be used as

pre-emergence herbicides for the management of *P. minor.* Further studies are required to isolate and identify these herbicidal constituents.

REFERENCES

Akbar M, Javaid A (2010). Management of some problematic weeds of wheat by metabolites of *Drechslera* spp. prepared in malt extract. Pak. J. Weed Sci. Res., 16: 145-151.

Balyan RS, Malik RK (1989). Influence of nitrogen on competition of wild Canarygrass (*Phalaris minor* Ritz) in wheat (*Triticum aestivum* L.). Pestology, 13: 5-6.

Bibi S, Marwat KB, Hassan G, Khan NM (2008). Effect of herbicides and wheat population on control of weeds in wheat. Pak. J. Weed Sci. Res., 14: 111-119.

Cheema MS, Akhtar M, Iqbal MS (2006). Performance of different herbicides in wheat under irrigated conditions of southern Punjab, Pakistan. Pak. J. Weed Sci. Res., 12: 53-59.

Chhokar RS, Singh S, Sharma RK (2008). Herbicides for control of isoproturon-resistant littleseed canarygrass (*Phalaris minor*) in wheat. Crop Prot., 27: 719-726.

Chhokar RS, Malik RK (1999). Effect of temperature on the germination of *Phalaris minor* Retz. Indian J. Weed Sci., 31: 73–74.

Chhokar RS, Malik RK, Balyan RS (1999). Effect of moisture stress and seeding depth on germination of littleseed Canarygrass (*Phalaris minor* Retz.). Indian J. Weed Sci., 31: 78–79.

Cuthbertson AGS, Murchie AK (2005). Economic spray thresholds in need of revision in Northern Irish Bramley orchards. Biol. News, 32: 19.

Devine MD, Shukla A (2000). Altered target sites as a mechanism of herbicide resistance. Crop Prot., 19: 881-889.

Evidente A, Andolfi A, Vurro M, , Zonno MC, Motta A (2005). Drazepinone, a trisubstituted tetrahydronaphthofuroazepinone with herbicidal activity produced by *Drechslera siccans.* Phytochemistry, 66: 715-721.

Evidente A, Andolfi A, Cimmino A, Vurro M, Fracchiolla M, Charudattan R (2006). Herbicidal potential of ophiobolins produced by *Drechslera gigantea*. J. Agric. Food Chem., 54: 1779-83.

Holm L, Pancho JV, Herberger JP, Plucknett DL (1979). A geograpical atlas of world weeds. Wiley, New York.

Javaid A, Bajwa R, Rabbani N, Anjum T (2007). Comparative tolerance of rice (*Oryza sativa* L.) genotypes to purple nutsedge (*Cyperus rotundus* L.) allelopathy. Allelopathy J., 20: 157-166.

Javaid A, Adrees H (2009). Parthenium management by cultural filtrates of phytopathogenic fungi. Nat. Prod. Res., 23: 1541-1551.

Javaid A, Ali S (2011). Herbicidal activity of culture filtrates of *Trichoderma* spp. against two problematic weeds of wheat. Nat. Prod. Res., 25: 730-740.

Javaid A, Javaid A, Akbar M (2011). Herbicidal potential of culture filtrates of *Drechslera* spp. against *Parthenium hysterophorus.* Chilean J. Agric. Res., 71: 634-637.

Marin A, Oliva J, Garcia C, Navarro S, Barba A (2003). Dissipation rates of cyprodinil and fludioxonil in lettuce and table grape in the field and under cold storage conditions. J. Agric. Food Chem., 51: 4708-4711.

Mehra SP, Gill HS (1988). Effect of temperature on germination of *Phalaris minor* Retz. and its competition in wheat. J. Res. Punjab Agric. Univ., 25:529–533.

Palmer CS, Saleeba JA, Lyon BR (2005). Phytotoxicity on cotton ex-plants of an 18.5 kDa protein from culture filtrates of *Verticillium dahliae*. Physiol. Mol. Plant Pathol., 67: 308-318.

Qureshi R, Bhatti GR (2001). Determination of weed communities in wheat field of district Sukhur. Pak. J. Bot., 33: 109-115.

Rial-Otero R, Arias-Estévez M, López-Periago E, Cancho-Grande B, Simal-Gándar J (2005). Variation in concentrations of the fungicides tebuconazole and dichlofluanid following successive applications to greenhouse-grown lettuces. J. Agric. Food Chem., 53: 4471–4475.

Siddiqui I, Bajwa R, Huma Z, Javaid A (2010). Effect of six problematic weeds on growth and yield of wheat. Pak. J. Bot., 42: 2461-2471.

Siddiqui I, Bajwa R (2001). Variation in weed composition in wheat fields of Lahore and Gujranwala divisions. Pak. J. Biol. Sci., 4: 492-504.

Singh S, Kirkwood RC, Marshall G (1999). Biology and control of *Phalaris minor* Retz. (littleseed Canarygrass) in wheat. Crop Prot., 18: 1–16.

Singh S, Malik RK, Balyan RS, Singh S (1995). Distribution of weed flora of wheat in Haryana. Indian J. Weed Sci., 27: 114–121.

Steel RGD, Torrie JH (1980). Principles and procedures of statistics. A biometrical approach. 2nd edition. McGraw Hill Book Co. Inc. New York, USA.

Sugawara F, Strobel G, Strange RN, Siedow JN, Van Duyne GD, Clardyv J (1987). Phytotoxins from the pathogenic fungi *Drechslera maydis* and *Drechslera sorghicola.* Proc. Natl. Acad. Sci. USA, 84: 3081-3085.

Thakur C (1984). Weed ScienceNew Delhi, India.: Metropoliton Book Co. Pvt. Ltd.

Tollennaar M, Aguilera A, Nissanka SP (1997). Grain yield is reduced more by weeds interference in an old than in a new maize hybrid. Agron. J., 89: 239-246.

Wright A, Egan S, Westrup J, Grodecki A (2001). Weed management for successful plant establishment. Vegetation Series, vol. 48. Department of Natural Resources and Mines, The state of Queensland, Australia.

Yuan JS, Tranel PJ, Stewart CN (2007). Non-target-site herbicide resistance: a family business. Trends Plant Sci., 12: 6-13.