Allelopathic effects of *Triticum speltoides* on two important weeds of wheat

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Abstract

The allelopathic effect of seven accessions of *Triticum speltoides* L. (a wild relative of wheat) on *Avena fatua* L. (wild oats), nine accessions on *Sisymbrium orientale* L. (Indian hedge mustard) and ten accessions on both species was evaluated using an agar diffusion method. This study was conducted as part of a broader attempt to evaluate the suitability of *T. speltoides* as a donor of an allelopathic trait to wheat to produce a new cultivar with weed suppressing ability. Pre-germinated seedlings of surface sterilized caryopses of *T. speltoides* were transplanted on to an agar (5 g L^{-1}) surface contained within a tube of cellulose dialysis membrane. The tube of cellulose dialysis membrane was held vertically within a 1.5 L plastic box partially filled with 1 L of agar (5 g L^{-1}). Surface sterilized caryopses of *A. fatua* or seed of *S. orientale* were sown onto the agar surface of the box at various distances from the *T. speltoides* seedling. Following two or six weeks (for *A. fatua* and *S. orientale*, respectively) the weed seedlings were removed from the agar and their radicle lengths recorded. Among the 17 *T. speltoides* accessions tested against *A. fatua*, accession 9 was the only one that significantly reduced radicle length (50%) across the width of the plastic box. Among the 19 accessions of *T. speltoides* tested against *S. orientale*, accession 8 (50%) and accession 10 (18%) were the only ones that significantly reduced length across the width of the plastic box. None of the accessions tested had the ability to suppress radicle growth of both weed species.

Introduction

Allelochemicals affect germination, growth, development, distribution, and behaviour of many plants including weeds (Wink 1987, Rizvi and Rizvi 1992, Fujii *et al.* 1995). Various scientists (Alteri 1988, Einhellig and Leather 1988, Einhellig and Frank 1995) have argued that if a crop possessed allelopathy this could provide an alternative, chemical-free weed management strategy for that crop. There are a few reports of allelochemicals being produced by crops; these include some cultivars of sunflower (*Helianthus annuus* L.), sorghum (*Sorghum bicolor* Moench.), rye (*Secale cereale* L., Einhellig and Leather 1988) and barley (*Hordeum vulgare* L., Lovett and Hoult 1992). In addition, very few scientists have selected for allelopathic activity during the breeding of these or other crops. A crop with an allelopathic potential would not only reduce the amount of herbicide needed to control weeds but would reduce the risk of herbicide resistance developing in those weed species and would also contribute an extra dimension to the ways in which crop rotation could be undertaken (Lovett and Knights 1996). For those crop species without an allelopathic trait present in any of their germplasm the trait could be introduced from another source (Macias 1995). However, such attempts to genetically manipulate crops in this way is scarce in the literature.

Triticum speltoides L., a wild relative of wheat, is reported to produce hydroxamic acid, a substance with allelopathic activity (Niemeyer *et al.* 1992). If it is shown that this species has such an ability to suppress weed growth it would be a simple task to introduce this to wheat through a wide hybridization and, if necessary, by an embryo rescue technique. Once established the hybrids could be used in a breeding program to produce a new wheat cultivar with a natural ability to suppress weed growth. As an initial step in such a procedure it is necessary to identify which accessions of *T. speltoides* had the greatest capability to suppress weed growth. The present study reports on the effect of 26 accessions of *T. speltoides* on two common weeds of wheat crops *viz.* *Avena fatua* L. (wild oats) and *Sisymbrium orientale* L. (Indian hedge mustard), using a standard laboratory test (Fujii *et al.* 1995).

Materials and methods

Plant materials

Seeds of *A. fatua* and *S. orientale* were collected from plants growing in the Darling Downs region of south-east Queensland. After harvest the seeds were cleaned and stored at 25 ± 2°C for up to one year before use. At the time of experimentation seeds were selected, surface sterilized by washing in 70% ethanol for 3 minutes, then in 3% (v/v) sodium hypochlorite solution for 10 (*S. orientale*) or 20 (*A. fatua*) minutes followed by three rinses in sterile water. Seeds of 29 accessions of *T. speltoides* were obtained from the Australian Wheat Germplasm Collection (Tamworth, New South Wales, Australia) and surface sterilized using a technique identical to that used for *A. fatua*.

Laboratory screening procedure

In the study involving *A. fatua*, surface sterilized seeds of *T. speltoides* were pregerminated on agar (8 g L^{-1}; Bacto agar, Sigma Chemical Company, St. Louis, USA) contained in 9 cm diameter petri dishes. When the seedlings were three days old they were transplanted (one per test) into a tube of cellulose dialysis membrane (CDM) partially filled with 20 mL of agar (5 g L^{-1}). In the study involving *S. orientale* 5 to 6-day-old *T. speltoides* seedlings (one per tube) were transplanted onto the agar surface in the CDM.

A surface sterilized square plastic box (1.5 L) was partially filled with 1 L of agar (5 g L^{-1}). During this procedure the CDM was held in the centre, but to one side of the box using a plastic frame. Once the agar had solidified the frame was removed. Onto the surface of the agar in the box was placed either 30 surface sterilized caryopses of *A. fatua* or 150 surface sterilized seeds of *S. orientale*. The exact position of each seed was determined using a cardboard template laid onto the agar surface. This template provided distances of between 10 and 80 mm from the centre of the CDM to the seed. After placing the weed seed onto the agar surface, the boxes were covered with a transparent plastic film (Glad Products Ltd., Queensland, Australia) to reduce seedling desensitization and water loss from the agar medium. After two or six weeks of incubation (*A. fatua* and *S. orientale* respectively) at 20 ± 2°C under a continuous photoperiod (200 µmol m^{-2} s^{-1}; photosynthetic photon flux density) the seedlings were carefully washed from the agar and their radicle lengths measured. Using this setup (a modified method of Fujii *et al.* 1995) the allelopathic effect of seven accessions of *T. speltoides* on *A. fatua*, eight on *S. orientale* and ten on both weed species was examined.

Data analysis

Radicle length and the distance of the seedlings from the centre of the CDM were subjected to a regression analysis. A scattered plot diagram was generated for each accession of *T. speltoides* using the distance between the CDM and weed seedlings as an independent variable and the radicle length as dependent variable.

Table 1. The effect of various accessions of *Triticum speltoides* on the growth of *Avena fatua* and *Sisymbrium orientale* seedlings planted on agar.

Triticum speltoides Accession number	*Avena fatua* Slope	*Avena fatua* r^2	*Sisymbrium orientale* Slope	*Sisymbrium orientale* r^2
1	0.00	0.00	-0.02	0.02
2	–	–	-0.03	0.08
3	0.02	0.02	-0.04	0.12
4	-0.01	0.00	–	–
5	-0.03	0.04	0.01	0.00
6	-0.01	0.01	0.02	0.02
7	-0.02	0.03	0.01	0.00
8	–	–	0.07**	0.42**
9	0.09**	0.52**	–	–
10	-0.01	0.01	0.08**	0.29*
11	0.01	0.01	0.03	0.27
12	0.02	0.15	–	–
13	0.01	0.01	-0.05	0.07
14	0.00	0.00	–	–
15	-0.01	0.02	–	–
16	0.01	0.00	0.01	0.15
17	-0.02	0.03	–	–
18	-0.01	0.01	-0.02	0.13
19	0.00	0.00	–	–
20	–	–	0.01	0.01
21	–	–	-0.01	0.02
22	–	–	-0.02	0.02
23	–	–	-0.01	0.13
26	–	–	-0.02	0.01
28	–	–	0.12	0.42**
29	–	–	0.00	0.00

*,** Significantly different at P>0.05 or P>0.01 level respectively. A dash indicates the experiment was not undertaken.

r^2 To express uniformity of data.

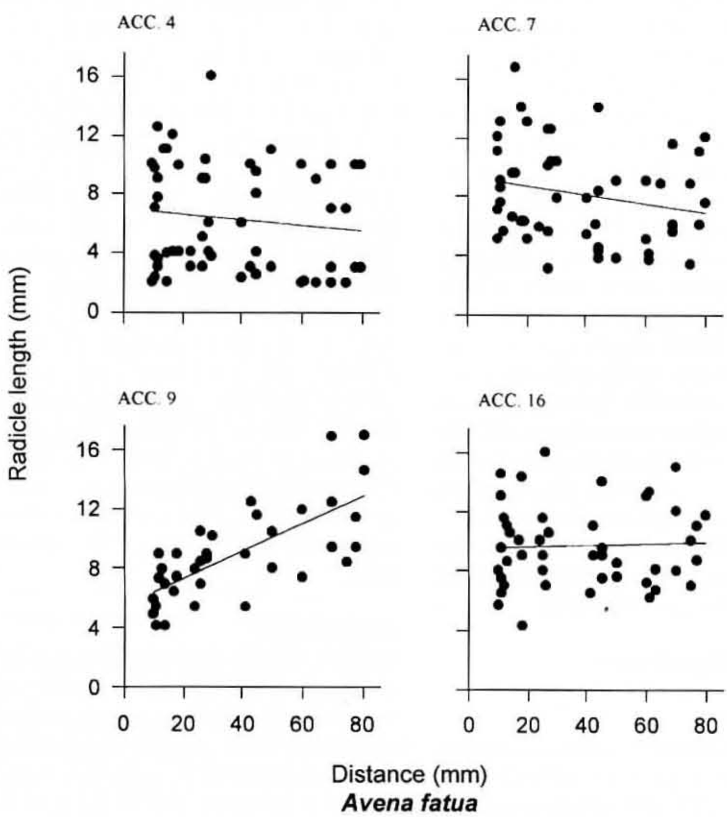

Figure 1. Scattered plots and the linear regression relationship quantifying the allelopathic effect of four accessions (4, 7, 9 and 16) of *Triticum speltoides* on the radicle length of *Avena fatua* seedlings sown onto agar between 10 and 80 mm away from the *T. speltoides* seedlings.

Results

The regression analysis showed that 16 of the 17 accessions of *T. speltoides* tested did not reduce radicle growth of *A. fatua* seedlings in agar (Table 1). Accession 9 (AUS No. 21645) was the only one to inhibit significantly radicle growth (Table 1 and Figure 1). Although the intercepts (P<0.001) of the linear regression equations for *T. speltoides* accessions 4, 7 and 16 were significant (Figure 1), the slopes were not significant (Table 1). The results for the other 13 accessions tested did not indicate an allelopathic interaction (Table 1).

Out of the 19 accessions of *T. speltoides* tested against *S. orientale*, only two, accessions 8 (AUS No. 21643) and 10 (AUS No. 21646), significantly reduced radicle growth (Figure 2). Although the intercepts (P<0.001) of the linear regression equations for *T. speltoides* accessions 2 and 6 were significant (Figure 2), the slopes were not significant (Table 1). The results for the other 15 accessions tested did not indicate an allelopathic interaction (Table 1).

Discussion

Triticum speltoides accession 9 tested against *A. fatua* and accessions 8 and 10 tested against *S. orientale* may release allelopathic substances which can significantly inhibit the radicle growth of one weed species. No one accession tested showed an allelopathic potential on both weed species under investigation. On average the radicle lengths of *A. fatua* and *S. orientale* seedlings sown between 10 and 20 mm away from the *T. speltoides* seedling (accession 9; accessions 8 and 10), were reduced by about 50%; 50 and 60% respectively when compared to those sown 70 to 80 mm away (Figures 1 and 2). The non-significant slopes of all other accessions indicate that these accessions did not significantly affect radicle growth of the weed species and are unlikely to release sufficient allelopathic substances to warrant further investigation (Table 1).

The present results indicate that of the accessions studied numbers 8, 9, and 10 of *T. speltoides* may provide the best source of allelopathic genes for transfer to wheat. Since the present experiments were conducted using an agar medium, further experiments should now be undertaken using a soil medium to confirm the present results and to test a wider range of weed species. After doing comprehensive work on possible deleterious allelopathic effects of *T. speltoides* on other weeds of wheat, its allelopathic potential could be exploited to produce a new wheat cultivar with the ability to inhibit the growth of some common weeds of wheat crops, just as weeds are inhibiting crop growth (Cheam 1996).

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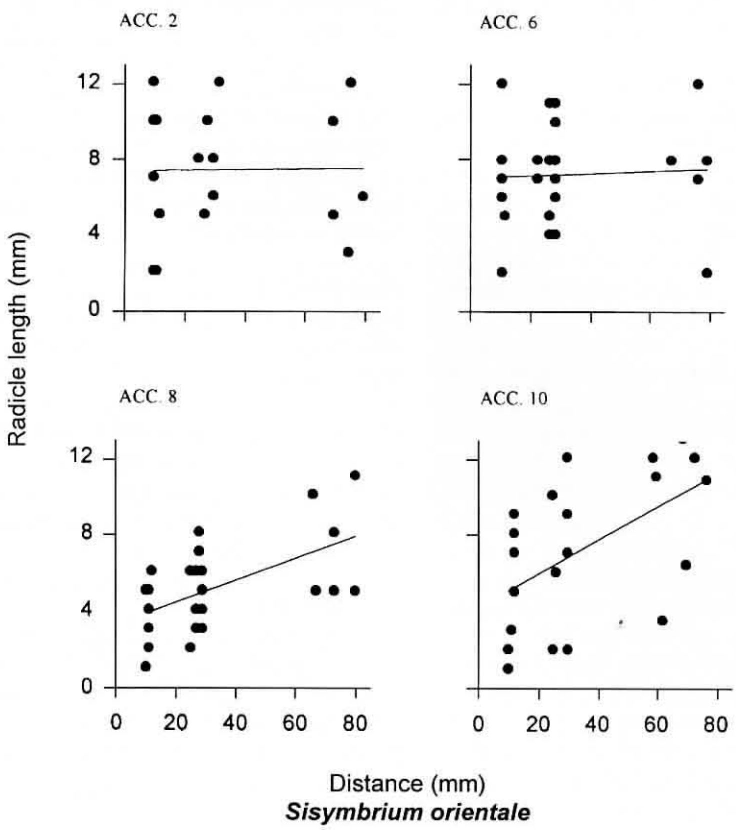

Figure 2. Scattered plots and the linear regression relationship quantifying the allelopathic effect of four accessions (2, 6, 8 and 10) of *Triticum speltoides* on the radicle length of *Sisymbrium orientale* seedlings sown onto agar between 10 and 80 mm away from the *T. speltoides* seedlings.