Interactions between Wild oat and a Weed-competitive and Non-competitive Wheat cultivar as influenced by Arbuscular Mycorrhizal Fungi

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Abstract

The response of a weed-competitive (Columbus) and non-competitive (Oslo) wheat (*Triticum aestivum* L.) cultivar, alone and in competition with wild oat (*Avena fatua* L.) to arbuscular mycorrhizal fungi (AMF) was assessed in a greenhouse study using four AMF species. Plants were inoculated with 300 spores of *Glomus clarum*, *G. etunicatum*, *G. intraradices* or *G. mosseae* and grown for 77 d in field soil containing low levels of indigenous AMF populations. The AMF species had no significant (P<0.05) effect on the shoot fresh or dry weight of single stands of Oslo or Columbus compared to the uninoculated controls. However, *G. etunicatum* significantly (P<0.05) enhanced the shoot fresh weight of single stands of wild oat, and *G. intraradices* significantly (P<0.05) increased the shoot fresh and dry weight of wild oat compared to the uninoculated control. The competitiveness of wild oat in competition with Oslo was significantly (P<0.05) enhanced by inoculation with *G. mosseae*, whereas the other AMF species had no effect. In contrast, inoculation of Oslo with *G. clarum* significantly (P<0.05) increased the ability of Oslo to withstand wild oat competition. On the other hand, there were no differences in the ability of any of the AMF species to impact on wild oat growth in competition with Columbus. However, *G. intraradices* significantly (P<0.05) increased the shoot dry weight of Columbus in competition with wild oat. These preliminary results indicate that different AMF species interact differently with various hosts, and that these interactions may be specific. In addition, it is apparent that these specific interactions may enhance the competitiveness of an incompetitive host against weeds.

Introduction

The success of weeds in natural ecosystems has been partially attributed to their association with soil microorganisms including arbuscular mycorrhizal fungi (AMF) (Callaway and Aschehoug, 2000). The AMF are soil fungi that are closely associated with more than 85% of plants and typically enhance plant growth. Ancient land races or genetically unmodified plant genotypes such as weeds or older crop cultivars appear to be more mycotrophic than the more recently developed crop cultivars (Hetrick et al. 1995; Xavier and Germida, 1998). It has also been hypothesized that this AMF discrimination more recently developed crop cultivars is the result of the inadvertent elimination of "mycorrhizal responsiveness" genes (Hetrick et al. 1995). The result is the more successful establishment of unmodified plants compared to the modified plants. Recent studies show that the competitiveness of a host can be modified by inoculating with AMF (Crush, 1995). Our study was aimed at assessing the impact of four different *Glomus* spp. on the competitiveness of wheat cultivars varying in weed competitiveness against wild oat.

Materials and methods

Soil

Plants were grown in a sandy loam soil collected from Dressler Farm, Saskatchewan. The following represents some of the important soil characteristics: N, 21 ppm; P, 11 ppm; K, 317 ppm; pH, 7.6. The soil contained <10 spores per 25 g soil.

Plant species

Weed: Wild oat (*Avena fatua* L.)
Crop: Wheat (*Triticum aestivum* L.) cv. Oslo (weed-incompetitive) and Columbus (weed-competitive) (Hucl et al. 1997).

AMF species

The following AMF species were obtained from the INVAM culture collection: *Glomus clarum* (Nicolson and Schenck), *Glomus etunicatum* (Becker and Gerdemann), *Glomus intraradices* (Schenck and Smith) and *Glomus mosseae* (Nicolson and Gerdemann) Gerdemann and Trappe. Spores were retrieved from monospecific AMF cultures by wet sieving and decanting followed by a sucrose (20%:60%) density gradient centrifugation step (Daniels and Skipper, 1982). Clean spores were suspended in 3 ml of water and stored at 4 C until used.

Treatments

(1) Wild oat only; (2) Oslo only; (3) Columbus only; (4) wild oat in competition with Oslo; (5) wild oat in competition with Columbus. Plants in all treatments were left uninoculated or inoculated with each of the four AMF species.

Inoculation and plant growth

About 400 g of field soil was filled in 4" square pots, moistened and allowed to equilibrate for 10 d before planting. Three hundred AMF spores per pot were placed as a spore plug at 5-cm depth from the soil surface. Two germinated healthy and uniform seeds were placed on the AMF spore plug, and thinned to one per pot after emergence. Plants were grown for 11 weeks and harvested.

Statistics

The study consisted of 25 treatments (5 AMF treatments $\times$ 5 plant treatments) each replicated three times. The study was repeated. Results from both trials were not significantly different from each other at P<0.05 and therefore, results from both trials were pooled. All data were subjected to the GLM procedure in SAS (1997) and means separated using the least significant difference (LSD) test. All percentage values were subjected to angular transformation before analysis. Unless otherwise mentioned, treatments were considered significant at P<0.05.

Results

Dry matter production

All the AMF species significantly enhanced the shoot dry weight of wild oat alone compared to the uninoculated control, whereas Oslo and Columbus without competition from wild oat did not benefit from any of the AMF species (Table 1A).

Table 1A. Mean (n=6) shoot dry weight of plants (g/pot) inoculated with the AMF species *Glomus clarum*, *Glomus etunicatum*, *Glomus intraradices* and *Glomus mosseae* and grown for 11 weeks in soil containing indigenous AMF. *LSD*- Least Significant Difference

Plant treatment	AMF treatment				
	Control	Glomus clarum	Glomus etunicatum	Glomus intraradices	Glomus mosseae
[a]Wild oat	0.86	1.48*	1.49*	2.02*	1.42*
[b]Oslo	1.61	1.41	1.19	1.50	1.19
[e]Columbus	1.43	1.15	1.59	1.49	1.27
[c]WO + os	0.13	0.17	0.97*	0.53	1.20*
[d]wo + OS	0.39	1.54*	1.32*	0.73	0.82
[f]WO + cl	0.40	0.30	0.41	0.66	1.29*
[g]wo + CL	1.00	1.38	1.06	0.96	0.75
LSD (0.05)	0.50				

[a]wild oat without competition; [b]Oslo without competition; [c]Columbus without competition; [d]wild oat in competition with Oslo; [e]Oslo in competition with wild oat; [f]wild oat in competition with Columbus; [g]Columbus in competition with wild oat.
*Treatments that are significantly different from control for each plant treatment.

Interactions between AMF species and the different plants varied significantly. For example, the AMF species *G. etunicatum* and *G. mosseae* significantly enhanced the shoot dry weight of wild oat in competition with Oslo compared to the control. On the other hand, the shoot dry weight of Oslo in competition with wild oat was enhanced significantly over the control plants by *G. clarum* and *G. etunicatum*. In contrast to wild oat in competition with Oslo, the shoot dry matter production of wild oat in competition with Columbus was enhanced only by *G. mosseae* (Table 1A). None of the AMF species enhanced the shoot dry matter production of Columbus in competition with wild oat, compared with the uninoculated control.

Shoot dry weight of uninoculated Oslo was significantly reduced in the presence of wild oat compared to single stands of Oslo, whereas the cultivar Columbus was able to compete effectively against wild oat (Table 1B). However, three of the four AMF species enhanced the weight of Oslo in competition with wild oat maintaining the weight of single stands of Oslo even when competing against wild oat. In contrast, the shoot dry weight of Columbus in competition with wild oat was significantly reduced by three of the four AMF species compared to single stand weights of Columbus (Table 1B).

Table 1B. Mean (n=6) shoot dry weight of plants (g/pot) inoculated with the AMF species *Glomus clarum*, *Glomus etunicatum*, *Glomus intraradices* and *Glomus mosseae* and grown for 11 weeks in soil containing indigenous AMF. *LSD*- Least Significant Difference

Plant treatment	AMF treatment				
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[f]WO + cl	0.40	0.30	0.41	0.66	1.29
[g]wo + CL	1.00	1.38	1.06*	0.96*	0.75*
LSD (0.05)	0.50				

[a]wild oat without competition; [b]Oslo without competition; [c]Columbus without competition; [d]wild oat in competition with Oslo; [e]Oslo in competition with wild oat; [f]wild oat in competition with Columbus; [g]Columbus in competition with wild oat.
Empty arrow refers to comparison of single stands of Oslo to Oslo in competition with wild oat, and filled arrow refers to comparison of single stands of Columbus to Columbus in competition with wild oat.
*Asterisks indicate weight of plants in competition treatments that are significantly different from the single stand treatments.

Proportion of total shoot dry matter

The proportion of total shoot dry matter was calculated using the shoot dry matter of plants. Results indicated that the relatively older Oslo was more competitive than the relatively newer Columbus when competing with wild oat, regardless of the inoculation treatment (Fig. 1).

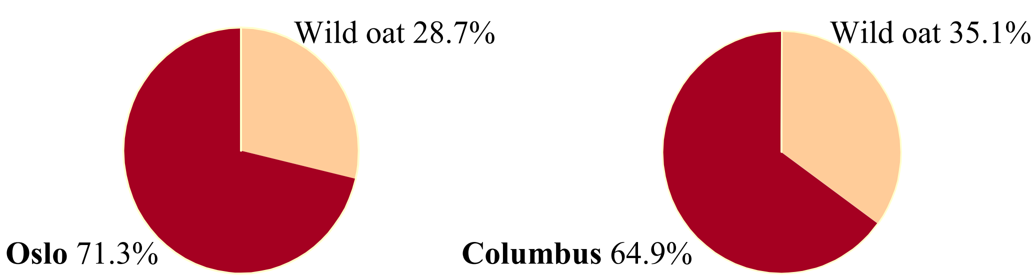

Figure 1. Proportion of total shoot biomass of wild oat and wheat cultivars Oslo and Columbus regardless of the inoculation treatment.

None of the AMF species significantly altered the proportion of shoot dry matter of the wild oat and Oslo competition or wild oat and Columbus competition compared to the uninoculated control. However, there were significant differences between the AMF species in their ability to boost wild oat or Columbus growth (Table 2). For example, the proportion of Columbus shoot dry matter in competition with wild oat was significantly enhanced by *G. clarum* compared to that of *G. intraradices*-inoculated wild oat.

Table 2. Mean (n=6) proportion of shoot dry matter of wild oat and Oslo (OR) wild oat and Columbus in competition with or without the AMF species *Glomus clarum*, *Glomus etunicatum*, *Glomus intraradices* and *Glomus mosseae* after 11 weeks' growth in soil containing indigenous AMF. Means in a column with the same letter are not significantly different.

AMF treatment	Proportion of total shoot dry matter (%)			
	Wild oat-Oslo	Oslo-wild oat	Wild oat-Columbus	Columbus-wild oat
None	28.35a	71.65a	36.66ab	63.34ab
Glomus clarum	16.91a	83.09a	20.07b	79.93a
Glomus etunicatum	34.28a	65.72a	32.98ab	67.02ab
Glomus intraradices	32.55a	67.45a	45.92a	54.08b
Glomus mosseae	31.64a	68.37a	39.78ab	60.22ab

The root fresh and dry weights of plants with or without competition were not altered by inoculation with any AMF species (data not shown).

Mycorrhizal colonization

There were significant differences between the different plant treatments in their AMF colonization levels (data not shown). However, there was no relationship between AMF colonization and shoot dry weight or the proportion of total shoot dry matter production.

Summary

- Interactions between wild oat and the wheat cultivars were significantly influenced by the AMF species.
- Wild oat plants benefited significantly more from AMF inoculation than Oslo or Columbus.
- The competitiveness of the relatively older cultivar Oslo against wild oat was enhanced by some AMF species, whereas the competitiveness of the relatively newer cultivar Columbus was reduced by some AMF species.
- Oslo benefited to a greater extent from AMF inoculation than Columbus when in competition with wild oat.
- Mycorrhizal colonization of roots was not correlated with the shoot dry matter or proportion of total shoot dry matter production of plants.
- Studies are currently underway to determine the mechanism(s) of action using model systems.

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