Arbuscular Mycorrhizal Fungi Influence Competition Between Barley and Wild Oat

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Abstract

Arbuscular mycorrhizal fungi (AMF) are soil fungi that intimately associate with most crops and influence their productivity. This study determined (i) the mycorrhizal dependency of eight barley cultivars and (ii) whether barley competitiveness against wild oat was linked to its mycorrhizal dependency. Of the eight cultivars tested, Virden was the most dependent on AMF whereas CDC Earl was the least dependent; Earl and Virden were therefore evaluated for competitiveness against wild oat at weed density ratios of 1:0.5, 1;1, 1:2 and 1:4 with or without AMF. Regardless of the AMF treatment, the total shoot dry weight of both barley varieties decreased with increasing crop:weed ratio. Earl derived 32% less benefit than Virden at a crop:weed ratio of 1: 0.5, and at a crop:weed ratio of 1:1, the total shoot dry weight of wild oat competing against Virden was significantly lower than that of wild oat competing against Earl. Regardless of the crop:weed ratio, (i) both barley varieties responded positively to the AMF mixture, (ii) the total shoot dry weight of AMF-inoculated Virden was 13% higher than that of AMF-inoculated Earl, and (iii) the shoot dry matter ratio of barley:wild oat was greater for AMF-inoculated Virden than Earl. At crop: weed ratios of up to 1:1, AMF-inoculated Virden plants had significantly more total shoot biomass than uninoculated Virden, whereas this was not the case with Earl. In general, wild oat competing against AMF-inoculated Virden had the least shoot dry matter at all the crop:weed ratios compared to all other treatments. These results suggest that the highly mycorrhizal Virden appeared to be more competitive than Earl and indicates that barley competitiveness may be partially linked to its mycorrhizal dependency.

Introduction

Arbuscular mycorrhizal fungi (AMF) are soil fungi that form an intimate association with most crops and influence their productivity. The AMF are considered to be generalists, however, significant differences exist between the affinity of AMF for one host plant (or cultivar) versus another (Boyetchko and Tewari, 1995; Hetrick et al. 1995; Xavier and Germida, 1998). This affinity of AMF for specific crops or crop cultivars generally translates into enhanced plant benefits such as improved plant productivity and acquisition of nutrients, and disease control. 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). We propose that a highly mycorrhizal barley cultivar would better compete against wild oat than a less mycorrhizal barley cultivar. Therefore, our objective was to determine whether the competitiveness of barley against wild oat was linked to its mycorrhizal dependency.

Materials and methods

Experiment 1:

In a previous study investigating eight barley (*Hordeum vulgare* L.) cultivars (Candle, Condor, CDC Dolly, CDC Earl, Falcon, Harrington, AC Lacombe, Virden), Virden was highly responsive to AMF, whereas CDC Earl was least responsive (data not shown). Virden inoculated with AMF had 41% more dry matter than the uninoculated plants. In contrast, the productivity of CDC Earl inoculated with AMF was reduced by 28%. Therefore, these two cultivars were selected in experiment 2 to investigate the impact of AMF on barley competitiveness against wild oat.

Experiment 2:

Plant species: Barley cultivars CDC Earl, Virden and Wild oat (*Avena fatua* L.). Plants were grown for 11 weeks.

Soil: Field soil low in plant-available P (11 ppm). The soil contained <7 spores per 25 g soil.

AMF inocula: 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. Four grams (31 AMF propagules / 50 g) of an inoculant mix containing all four AMF species listed above.

Treatments: Three factors: 2 cultivars (Earl and Virden); 2 AMF treatments (with and without) and 4 crop:weed density ratios (1:0.5, 1:1, 1:2, 1:4). This experiment was repeated and replicated (n=3).

Inoculation and plant growth
Field soil was filled in 17.5 cm- dia. pots, moistened and allowed to equilibrate for 10 d before planting. Four grams of the AMF inoculant was spread as a layer at 5-cm depth from the soil surface. Barley seeds were placed in a row and thinned to four per pot after seedling emergence. Wild oat seeds were planted at random and thinned to two (for the 1:0.5 treatment), four (for the 1:1 treatment), eight (for the 1:2 treatment) and 16 (for the 1:4 treatment) after emergence. Plants were grown for 90 d and harvested.

Statistics
The study consisted of 16 treatments (2 cultivars × 2 AMF treatments × 4 crop:weed density ratios) 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

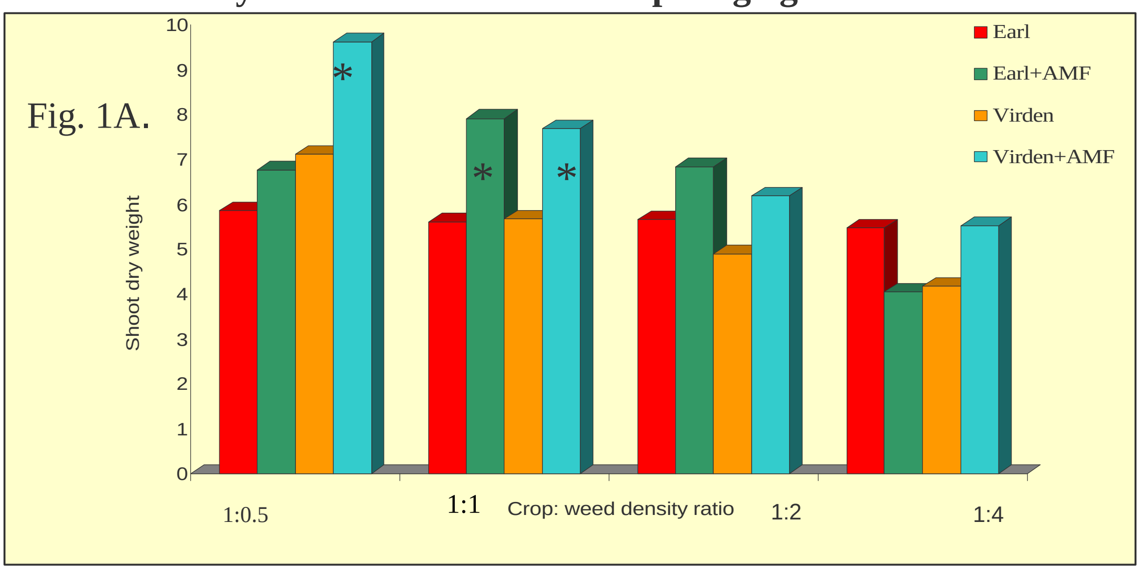
using the least significant difference (LSD) test. Unless otherwise mentioned, treatments were considered significant at *P*<0.05.

Results

Regardless of the crop:weed density ratio, both barley cultivars responded positively to the AMF inoculant. Virden response to AMF was 13% higher than that of Earl. Barley:wild oat shoot dry matter ratio was greater for inoculated Virden than Earl (data not shown). Regardless of the AMF treatment, barley shoot dry weight decreased with increasing weed density. Virden received a greater benefit (32% more) than Earl at a crop: weed ratio of 1:0.5. Shoot dry weight of wild oat competing with Virden was significantly lower than weight of wild oat competing against Earl, up to a crop: weed ratio of 1:1 (data not shown).

At crop: weed ratios of up to 1:1, AMF-inoculated Virden plants had significantly more total shoot dry weight than uninoculated Virden, whereas this trend was noted in Earl only at a crop:weed ratio of 1:1 (Fig. 1A).

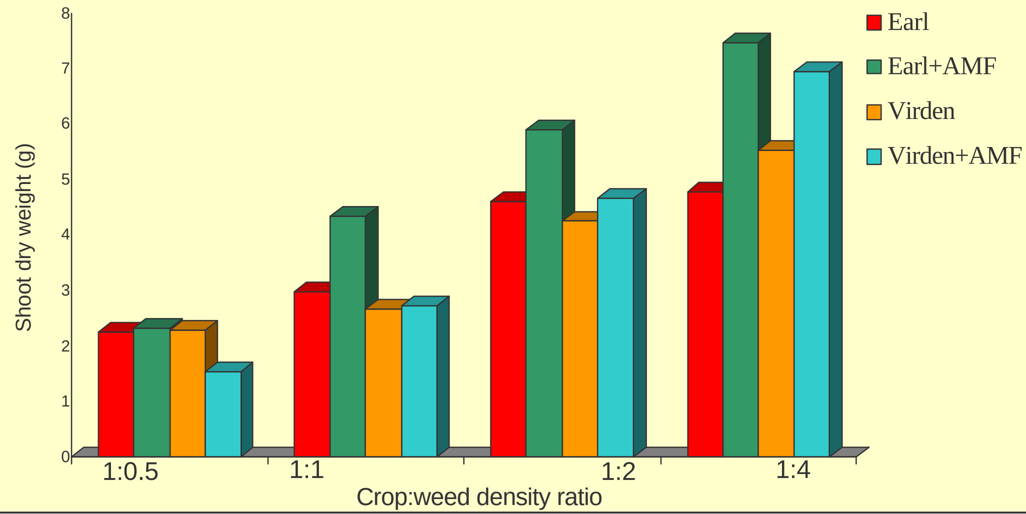
Shoot dry matter of BARLEY competing against wild oat



In general, wild oat competing against AMF-inoculated Virden had similar or lower shoot dry weights at all the crop:weed ratios (except 1:4) (Fig. 1B). However, shoot dry weights of wild oat competing against AMF-inoculated Earl generally was significantly greater than uninoculated Earl.

Shoot dry matter of WILD OAT competing against barley

Fig. 1B.



Summary

Preliminary results indicate that AMF-inoculated Virden was more competitive against wild oat compared to Earl. This was reflected in the enhanced shoot dry weights of Virden plants compared to the uninoculated plants. Shoot dry matter data suggests that AMF-inoculated Virden is more competitive than Earl because of enhanced dry matter production in the presence of the AMF inoculant mix and significant reductions in the weight of wild oat plants competing against them. The impact of AMF on barley competitiveness against wild oat will be evaluated using selection criteria that includes dry matter production and nutrient analyses, which is in progress. Additional studies are also underway to determine the mechanism(s) involved in enhanced competitiveness of Virden mediated by AMF.

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