Soil biota influence invasion within microhabitats in a California coastal prairie

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Abstract

This study compared biomass accumulation and emergence of a common native grass (*Hordeum brachyantherum*) and a prolific non-native (*Bromus diandrus*) on live and sterile soils from native grassland and from the rhizospheres of *L. arboreus* and *B. diandrus* in order to determine the effect of soil microbiota. Results showed that although lupine soil increases the biomass of *B. diandrus* due to increased nitrogen, this effect is diminished by the presence of soil biota; biomass of *B. diandrus* increased by 13.5% on sterile lupine soil. While *B. diandrus* biomass was reduced by 21.8% on sterilized grassland soil, *H. brachyantherum* biomass was increased by 12.9%. Emergence of *H. brachyantherum* was also increased on sterilized grassland soil by 58.3%. Emergence of *B. diandrus* increased by 11.8% on sterile grassland soil, 11.1% on conspecific soil, and 26.7% on sterile lupine soil.

Both emergence and biomass of *B. diandrus* were most inhibited by lupine soil biota, and *H. brachyantherum* was much more inhibited by grassland soil biota than *B. diandrus.*

Introduction

Only a small proportion of introduced plant species become aggressive invaders. Recent research has shown that relationships between plants and soil biota are key in determining the invasibility of an ecosystem (Reinhardt and Callaway 2006, Klironomos 2002). Additionally, the ease with which an invasive plant becomes established is known to vary across microhabitats (Kolb *et al.* 2002).

Within a single landscape, many microhabitats may exist; defined by variation in nutrient availability, water availability, abiotic and biotic soil characteristics, and microclimate. Increased nitrogen availability in soil influenced by *Lupinus arboreus* has been shown to facilitate invasive grasses on the Bodega Marine Reserve (BMR) (Maron and Connors 1996). Although nutrient availability is of great importance, there are numerous other factors that determine the invasibility of a microhabitat; this study focuses on the role of soil microbiota to add to previous research.

The Bodega Marine Reserve (BMR) and lab.

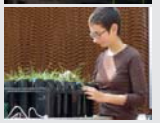
In order to better understand biotic soil factors influencing invasion, this study examined how soil communities from differing microhabitats on the BMR affect the growth of both the native grass *Hordeum brachyantherum* and the non-native *Bromus diandrus*.

The objectives of this study were:
(i) to determine whether soil biota from lupine and grassland rhizospheres differentially influence the speed and rate at which *B. diandrus* and *H. brachyantherum* emerge, (ii) to determine whether biomass accumulation is affected by soil biota, and (iii) to compare the relative feedbacks of conspecific soil on the emergence and biomass accumulation of both grasses.

Experimental design

Lupines and native grassland on the BMR; one site of soil collection.

Soil was collected from underneath:
large lupines ("lupine" type)
native grassland ("grassland" type)
and individuals of *Bromus diandrus* (not pictured) ("invaded" type)



Above: Plants were grown in the Mills College greenhouse.

The majority of the soil was sterilized using an autoclave, and then half each soil type was re-inoculated with 1/5 volume unsterilized soil to create "live" and "sterile" subtypes.

20 seeds of *B. diandrus* were sown on live and sterile soil of all three types. 20 seeds of *H. brachyantherum* were sown on live and sterile soil from lupine and grassland types. Emergence was recorded, and dry biomass measured after 42 days.

RESULTS: Biomass accumulation

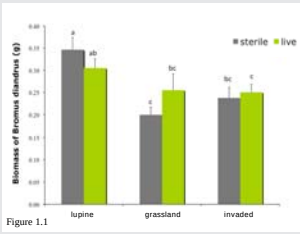


Figure 1.1

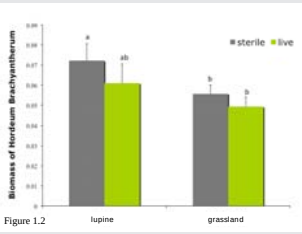


Figure 1.2

- Biomass accumulation of both species was higher on lupine soil than other soils ($P = 0.0005$ overall; Fig. 1.1, 1.2), due to higher nitrogen content in the lupine soil.
- While *B. diandrus* biomass increased slightly on live grassland and invaded soils, it decreased on live lupine soil (Fig. 1.1).

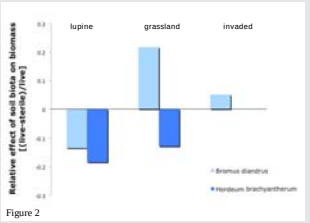


Figure 2

- On native grassland, *B. diandrus* has a distinct advantage: Biomass increased 21.8% in the presence of soil biota. *H. brachyantherum* biomass decreased 12.9% in live soil (Fig. 2). Is *B. diandrus* experiencing enemy release?
- This advantage decreased on invaded soil – does *B. diandrus* accumulate specific pathogens over time?

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RESULTS: Rate of emergence

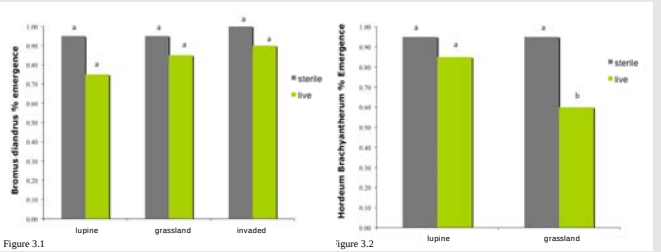

Figure 3.1 Figure 3.2

- Emergence of both species was higher on sterile soil ($P = 0.001$ overall, Fig. 3.1, 3.2).
- However, for *B. diandrus* there were no significant differences between live and sterile for individual soil types. Live lupine soil reduced emergence the most ($P = 0.09$ compared to sterile lupine soil, Fig. 3.1).

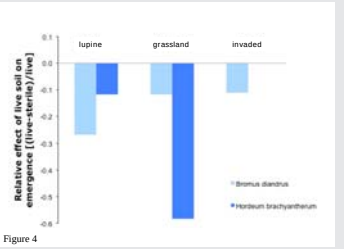

Figure 4

- *H. brachyantherum* emergence decreased significantly on live grassland soil ($P = 0.001$), but not significantly on live lupine soil ($P = 0.3$, Fig. 3.2).
- *B. diandrus* emergence increased 26.7% in sterile lupine soil; *H. brachyantherum* increased 58.3% in sterile grassland soil (Fig. 4).

RESULTS: Time until emergence

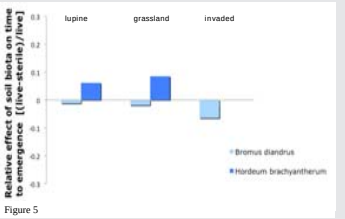

Figure 5

- Differences in the length of time until emergence were not significant between soil types.
- However, an interesting trend was noted: *B. diandrus* emerged faster on live soil, and *H. brachyantherum* emerged faster on sterile soil ($P = 0.13$, Fig. 5).
- Is there an advantage to germinating faster in the presence of soil biota?

Conclusions

Although biomass accumulation of *B. diandrus* is increased by the elevated nitrogen in lupine soil, lupine soil fosters biota which negatively impact *B. diandrus* compared with surrounding microhabitats. Similar to the effect on biomass, emergence of *B. diandrus* was most inhibited by lupine soil biota, while *H. brachyantherum* was most inhibited by native grassland soil biota.

In native grassland, soil biota give *B. diandrus* an advantage over the native *H. brachyantherum*, but this advantage is not present in lupine rhizospheres where antagonists exist. In addition, the increase in biomass of *B. diandrus* seen in native grassland soil declines in grassland where *B. diandrus* is already established.