



Reduced vigor of a clonal invader: Lack of evidence for soilborne pathogens



Rafael Otfinowski^{a,*}, Norm C. Kenkel^a, Mario Tenuta^b

^a Department of Biological Sciences, University of Manitoba, 190 Dysart Road, Winnipeg, MB R3T 2N2, Canada

^b Department of Soil Science, University of Manitoba, 309 Ellis Building, 13 Freedman Crescent, Winnipeg, MB R3T 2N2, Canada

ARTICLE INFO

Article history:

Received 4 April 2015

Received in revised form 20 September 2015

Accepted 24 September 2015

Available online 27 October 2015

Keywords:

Biological invasion

Negative feedback

Plant parasitic nematodes

Northern fescue prairie

Smooth brome

Restoration

ABSTRACT

Predicting the impacts of exotic species on native ecosystems requires an understanding of the ecological processes that regulate biological invasions. Despite accumulating evidence that belowground interactions play a significant role in determining the outcome of plant invasions, few studies have examined the role of soilborne pathogens in invasion dynamics. We tested the hypothesis that accumulating negative plant–soil feedbacks reduce the vigor of clones of smooth brome (*Bromus inermis*), invading northern fescue prairies in Manitoba, Canada. We examined the density, biomass, and height of ramets of smooth brome from the center of invading clones to their fringes and tested the negative plant–soil feedback hypothesis using plant parasitic nematodes and soilborne pathogens. Ramets of smooth brome were less vigorous inside the invading clones compared with those along the fringes. The observed loss of vigor inside the clones was not related to plant parasitic nematodes or soilborne pathogens. Fewer soilborne plant parasitic nematodes were found at the center of invading clones and pasteurization had no effect on the mass of seedlings raised in soil collected in this area. Higher available soil nitrogen, phosphorus, and soil moisture at the center of invading clones suggest senescence in the older areas of the clone. However, other hypotheses, including potential impacts of other groups of plant pathogens and autotoxic effects from the accumulating litter, remain unexplored. Despite the reduced vigor of smooth brome at the center of invading clones, plant communities in this area remained less diverse. Future restoration of native prairies invaded by smooth brome will require active methods to reverse these negative impacts.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Control of exotic organisms requires an understanding of both their impacts on native ecosystems and the ecological processes that regulate their invasions. Accumulating evidence that biotic interactions belowground play a significant role in determining the outcome of plant interactions (Bever, 2003) promises important insights into mechanisms that determine the success of biological invaders. Among complex, multi-trophic interactions between plants and soilborne organisms, soilborne pathogens remain a poorly studied element of invasion dynamics (Eppinga et al., 2006).

Pathogens affect host populations and communities of plants through their impacts on the survival, growth and fecundity of individuals (Gilbert, 2002). Losses of carbon and nutrients to enemies result in lower growth rates and decreased primary

productivity (Mitchell, 2003). Negative feedbacks between plants and soilborne pathogens also help maintain local community diversity by preventing individual species from increasing in dominance (Bonanomi et al., 2005; Mangan et al., 2010). Negative feedbacks are favored where both pathogens and hosts have limited dispersal (Gilbert, 2002). For example, at the interface of plant roots and soil, host-specific microorganisms, including root feeding nematodes and pathogenic fungi, may accumulate over time, increasing their biological effects on their host (Bever, 2003).

Declines in the vigor of monospecific stands of perennial plants are well documented in both natural and cultivated ecosystems. Along coastal dunes, reductions in the height and density of beachgrass (*Ammophila arenaria* (L.) Link) have been attributed to the gradual accumulation of pathogenic nematodes (de Rooij-van der Goes, 1995). Nematodes and pathogenic fungi are also responsible for declines in the vigor of red fescue (*Festuca rubra* L.) and sand sedge (*Carex arenaria* L.) in the Netherlands (Olf et al., 2000) and the successional dynamics of foredune and temperate forest vegetation (van der Putten et al., 1993; Packer and Clay,

* Corresponding author at: University of Winnipeg, 515 Portage Avenue, Winnipeg, MB R3B 2E9, Canada. Fax: +1 204 774 2401.

E-mail address: r.otfinowski@uwinnipeg.ca (R. Otfinowski).

2003). Perennial crops are also susceptible to accumulating populations of pathogens. For example, the management of crop residues and soil microbial communities remains key to the suppression of the take-all patch fungus (*Gaeumannomyces graminis* (Sacc.) Arx & D. Oliver) and other soilborne pathogens (Cox et al., 2005).

The strength of the feedback between plants and soilborne pathogens is often a function of the age, the size, and the density of host populations (Carlsson et al., 1990; Packer and Clay, 2003). In crop monocultures, cumulative losses in plant productivity are often linked to qualitative and quantitative changes in communities of pathogens (Shipton, 1977). Often, yields can only be recovered by rotating crops and interrupting cycles of disease (Krupinsky et al., 2004). In native communities, negative feedbacks between soilborne pathogens and plants can also increase species turnover and maintain plant biodiversity (Petermann et al., 2008). For example, the observed disproportional mortality of seedlings near parent plants forms the basis of the escape hypothesis, which proposes a selective advantage of dispersal and predicts increased rates of infection among common species (Packer and Clay, 2003).

The link between disease incidence and the spatial structure of populations poses a unique problem for plant species forming dense, perennial stands, especially those that grow clonally. Compared with annual species, clonal perennial grasses are often associated with a greater number of fungal pathogens (Clay, 1995) and the observed central die-back among clonal species can be induced by the build-up of negative plant–soil feedback in the central, older areas of expanding clones (Carteri et al., 2012; Bonanomi et al., 2014). Higher parasite pressures are also been reported among perennial species in the family of Caryophyllaceae (Thrall et al., 1993) and larger hosts, such as shrubs and trees (Strong and Levin, 1979). Although exotic plants may have escaped native enemies, their long-term persistence may still depend on the build-up of pathogens (Dietz et al., 2010). For example, some exotic invaders do not maintain their invasive rank (Perrins et al., 1993) and gradually disappear from their introduced environments (Crawley, 1987). Especially vulnerable may be exotics that rapidly displace native species to form dense monocultures (Carlsson et al., 1990). Among the large number of exotic species in most regional floras, the ability to grow clonally, shared by the majority of successful invaders (Pyšek, 1997) might also be expected to contribute to their vulnerability to plant pathogens. For example, given that clonal growth can result in substantial lateral spread, large clones may provide bigger targets for pathogen colonization than smaller, individual plants (Clay and van der Putten, 1999).

In this study, we examine the role of soilborne pathogens in the decline of smooth brome (*Bromus inermis* Leyss.), a Eurasian perennial, invading native prairies throughout the Great Plains (Otfinowski et al., 2007). Widely planted for hay, forage, and to revegetate disturbed areas, smooth brome often escapes to establish in areas of native prairie, spreading clonally to produce dense monocultures that compromise the structure and function of invaded communities (Bennett et al., 2014). Despite its susceptibility to a high number of fungal pathogens (Clay, 1995), including species of the root pathogens, *Fusarium* and *Pythium*, and the root-lesion nematode *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans-Stekhoven (Otfinowski et al., 2007), existing research has not explored questions regarding the long-term persistence of smooth brome in native communities. The aim of our study was to examine the vigor of smooth brome clones invading native prairies. Using a combination of field surveys and greenhouse experiments, we examined the vigor of invading clones, from their centers to their invading fringes, and tested the hypothesis that accumulating negative plant–soil feedbacks at the center of invading clones will reduce their vigor.

2. Materials and methods

2.1. Study area

Research was conducted in Riding Mountain National Park, Manitoba, Canada (latitude: 50.6578, longitude: –99.9720). The park occupies an area of 2978 km² in western Canada and consists of large areas of rolling upland (550–640 m), underlain by glacial tills (Cody, 1988). The region is characterized by a mean annual precipitation of 475 mm, mean temperatures between –18 °C (January) and 18 °C (July), and a growing season of 170 days (Leeson et al., 2005). Riding Mountain National Park lies in the Mixedwood Section of the Boreal Forest Region and protects areas of northern fescue prairie (Cody, 1988). In North America, fescue prairies form an arc around the northern and northwestern perimeter of the mixed prairie, occupying a transition between the warmer and drier grasslands and the cooler, moister aspen parkland (Coupland and Brayshaw, 1953). Fescue prairies, dominated by rough fescue (*Festuca hallii* (Vasey) Piper) and species of *Elymus* and *Carex*, are threatened in western Canada by the impacts of grazing, cultivation and exotic species invasions (Trottier, 1986).

2.2. Surveys of invading clones

We randomly selected 34 clones of smooth brome invading two fescue prairies (Bob Hill and Strathclair) in Riding Mountain National Park (17 clones per prairie). Selected clones ranged from 120 to 1370 cm in diameter. The two prairies were situated approximately 50 km apart; soils at the more western Bob Hill prairie (latitude: 50.9187; longitude: –100.8865) were more xeric and lower in mineral nitrogen than the centrally located Strathclair prairie (latitude: 50.7932; longitude: –100.2401).

Based on a factorial design, we divided each clone into three areas (center, middle, and fringe) and used 50 × 50 cm quadrats, placed along transects (bearing: 135°), to measure the density, height, and biomass of brome ramets and to collect samples of root biomass, thatch and litter. Thatch and litter, defined as standing, fallen, and variously disintegrated residues of plants (Agriculture Canada, 1998), were not distinguished by species. During July 2005, ramets of smooth brome were clipped at the soil surface inside each quadrat, air dried (48 h, 60 °C), and weighed. We collected samples of root biomass from a subset of six clones per prairie ($n = 12$). Root cores were collected inside each quadrat using a hand auger (diameter: 5 cm) and separated by depth (0–10 cm, 10–30 cm). Cores were cleaned using a hydropneumatic root washer (Gillison's Variety Fabrication, Inc., Benzonia, MI), air dried (48 h, 60 °C), and weighed. No distinction was made between the roots of smooth brome and other species. During August 2004, we measured the vegetative cover of vascular plants at the center, middle, and along the fringes of invading clones using 1 × 1 m quadrats.

Quadrats at the center, middle, and fringes of invading clones were also used to collect soil samples for nitrogen and phosphorus extraction. In addition, we used in situ incubations to monitor changes in mineral nitrogen in all 34 clones (Binkley and Hart, 1989). Cores of soil, extracted using a hand auger (0–15 cm, 74 cm³), were placed in plastic Ziploc[®] bags, buried in the auger excavations, and incubated between July and August 2004. Soil incubations in plastic bags allow the exchange of oxygen and carbon dioxide (Gordon et al., 1987). Along with reference samples, collected at the time of installation, all soil samples were air dried, milled, extracted with 2.0 M KCl, and analyzed for ammonium and nitrate using a Technicon[®] AutoAnalyzer[®] II (Maynard and Kalra, 1993). Due to rodent damage, only results from undamaged incubation bags at one prairie are presented here (Strathclair, $n = 16$). We repeated our measurements of soil mineral nitrogen

Download English Version:

<https://daneshyari.com/en/article/4381859>

Download Persian Version:

<https://daneshyari.com/article/4381859>

[Daneshyari.com](https://daneshyari.com)