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Disturbances Impact on Longevity of Grass Seeds, Semi-Arid South African Rangeland

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Abstract

The effect of plant and soil disturbances on seed density, species richness, and seed longevity of the soil seed bank was quantified for a semi-arid rangeland, over a 5-yr period (2002/2003–2006/2007 growing seasons). The different soil and plant treatments included fire, tillage (intended as a trampling surrogate), and blocked seed rain (simulating heavy grazing). These three experimental factors were combined in a factorial arrangement. Seed responses were evaluated in the soil seed bank before the new seed set, after the first seed production event, and after the second seed production event. Before disturbance (physical impact on the plant and soil), soil seed bank was dominated by early successional species: conversely, aboveground vegetation was mainly dominated by perennial grasses. After only 4 yr of blocked seed rain, seedling emergence of Decreaser grass species ceased totally both in the field and seed bank, with lower effect on Increaser grass species. Emergence of both Decreaser and Increaser grass species decreased in the seed bank with tillage, whereas the opposite occurred in the field. By contrast, tillage increased the emergence of weeds in the seed bank. The decrease in emergence of Decreaser grass species in both seed bank and field was still evident 4 yr after the rangeland was burnt. The grass species *Themeda triandra* was the most sensitive to fire in terms of seedling emergence. Blocked seed rain treatment significantly decreased ($P < 0.05$) species richness. Regardless of treatments applied, there was poor similarity between aboveground vegetation and the associated seed bank. Differences in the soil seed bank are likely to reflect manifested properties rather than short-term changes. Several characteristics of seed banks (species composition, seed abundance, and longevity) must be considered in order to understand the dynamics of plant communities following disturbances.

Key Words: blocked seed rain, fire, seedling emergence, species richness, tillage

INTRODUCTION

The soil seed bank plays an important role in the composition of different plant communities and thus in their conservation (López-Mariño et al. 2000; Shauhat and Siddiqui 2004). The composition of the seed bank depends on the production and composition of the present and previous communities (Harrington et al. 1984; Fenner 1985) as well as on the longevity of the seeds of each species under local conditions (Bekker et al. 1997; Thompson and Grime 1997). Vegetation studies in grazing systems are mostly restricted to the aboveground vegetation, and often ignore the role that soil seed banks could play in the restoration of degraded vegetation communities after disturbance (de Villiers et al. 2003; Solomon et al. 2006; Amaha Kassahun et al. 2009; Dereber et al. 2011).

The trampling and removal of vegetation by animals or fire have a significant impact on the number of seeds produced by a plant and released as seed rain (Page and Beeton 2000; Snyman 2005). According to Chang et al. (2001), regeneration strategies of plants are shaped by patterns of disturbance and stress. These act as selective forces over evolutionary time. The presence of seeds in disturbed habitats is determined by the relationship between the original plant assemblages, the amount of propagule production, and the capacity to build up seed reserves in the soil (Kinucan and Smeins 1992; Chang et al. 2001). In rangeland management, it is critical to establish how far an ecosystem can deviate from a reference state before being at risk to cross a threshold into an alternative stable state from which it is unable to revert without active intervention (Briske et al. 2008; Dreber and Esler 2011). Once the seed bank changes, the resulting community structure will be different and therefore seed banks have the potential to represent a threshold.

In relatively undisturbed rangelands, the role played by seedling recruitment from the persistent seed bank in vegetation composition changes, and its importance compared with recent seed rain is not always clear (Bullock et al. 1994; Page and Harrington 2009). Edwards and Crawley (1999) argued that the extent of seedling recruitment from the seed bank and seed rain is not only significant to our general understanding of how plant species richness is maintained, but also has applied significance for attempts to restore species richness in species-poor grasslands (Page et al. 2006; Snyman 2009). Rangelands have a large, persistent seed bank, often with a species composition that does not resemble the aboveground vegetation (Thompson and Grime 1997; Amaha Kassahun et al. 2009), and it is well documented that these seeds can dictate the successional trends that occur following large-scale disturbances (Bekker et al. 1997; Edwards and Crawley 1999).

Worldwide, rangelands are subject to active management and these practices are based on a variety of criteria and constraints (Snyman 2009). Periodically, grazing and burning is commonly used to reduce competitive effects among plant species (Savory and Parsons 1980; Heitschmidt and Walker

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