Germination analysis of a seed bank along a degradation gradient in a semi-arid grassland

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Abstract
The germination potential of seed banks along a degradation gradient in a semi-arid grassland in South Africa was quantified in a greenhouse experiment. Soil samples were collected to a depth of 50 mm in late June 2000 from four sample sites, namely: bare soil, as well as veld in good, moderate and poor condition. The sample sites represented a vegetation degradation gradient of a semi-arid grassland. Only four grass species (Aristida congesta, Chloris virgata, Themeda triandra and Tragus racemosus) and two forbs species (Felicia muricata and Senecio consanguineus) were identified in the seed bank. Aboveground botanical composition was positively correlated with seed bank species composition ($R^2 = 0.94$). Long- and short-term management practices must be identified and implemented in the sensitive semi-arid regions. This will ensure the development of seed banks for sustainable succession patterns and plant population dynamics, leading to optimal livestock production.

Keywords: Botanical composition, population dynamics, veld management

Introduction
Livestock production in the pastoral parts of South Africa strongly depends on the condition of the available natural pasture. The capacity of degraded, over-exploited natural pasture to sustain high levels of livestock production is severely limited. The addition of seed to the soil seed bank is one of the strategies that plants have developed to survive in an unpredictable biotic and abiotic environment. The evaluation of the size and composition of the seed bank is important in understanding plant community development and succession patterns, which can be used to identify factors regulating population dynamics (Rees & Crawley, 1989). Recruitment of new individual plants from a seed bank at different times plays an important role in the composition, structure and dynamics of the vegetation. However, the role of seed banks in arid and semi-arid habitats in plant population dynamics, succession patterns and relation to the aboveground vegetation is poorly understood (Hassan & West, 1986). The composition of the seed bank depends on the composition and production of the present and previous plant communities as well as the longevity of the seed of each species under local biotic and abiotic conditions (López-Marinó et al., 2000). The persistence of plants often depends on seed banks (Baskin & Baskin, 1998). The decline of seed banks can be attributed to the reduction of species richness and seed production, increased soil erosion, a reduction in soil water content and changes in climatic conditions (Stamp & Lucas, 1983).

Against this background, this study was undertaken to quantify some characteristics of seed bank germinability along a degradation gradient in semi-arid grassland. Thereby it was attempted to gain insight in the recovery potential of degraded grassland.

Materials and Methods
The study was conducted in the Free State province (longitude – 28°51‘E; latitude – 26°59‘S; altitude 1350 metre above sea level). The experimental site was situated in the semi-arid summer rainfall (560 mm mean annual precipitation) region of South Africa. The vegetation type is described as dry sandy Highveld Grassland (Bredenkamp & Van Rooyen, 1996). The soil was a sandy-clay (Arcadia) with 36% clay, 19% silt, 45% sand and an effective depth of less than 1.2 m (Soil Classification Working Group, 1991). Twenty soil samples from each sampling area were collected to a depth of 50 mm in late June 2000. The soil samples were collected from four sample sites, namely: bare soil, as well as veld in good, moderate and poor condition. The sample sites represented a degradation gradient. A germination trial was conducted to
determine the species composition and size of the persistent seed bank. All samples were exposed to a 14-
day prechilling (3 to 5 °C) stratification treatment to simulate cold requirements for breaking seed dormancy. 
Each soil sample was placed to a depth of 20 mm into a 15 x 25 cm² plastic pot that had been filled with a 
sterile growth medium (Hygrotech) to improve the hydraulic conditions of the soil. Ten pots were filled only 
with the sterile growth medium and placed together with the other pots in the greenhouse to detect any 
contamination with seeds of weeds and other foreign plants. No contamination was detected in these control 
pots. Emerged seedlings were identified over a 30 day period and removed. When identification of a 
seedling was not possible, the seedling was planted in individual pots and allowed to grow until 
identification was possible. All data were analysed by using a one way analysis of variance (Steel & Torrie, 
1960). Least significant differences (LSD) were calculated at the 5% level.

Results and Discussion

Four grass species (Aristida congesta, Chloris virgata, Themeda triandra and Tragus racemosus) and 
two forb species (Felicia muricata and Senecio consanguineus) were identified in the seed bank. Aristida 
congesta occurred in all treatments except in veld in good condition. It was the only species that germinated 
on the bare soil. Tragus racemosus occurred in both the poor and moderate veld, while C. virgata occurred 
only in moderate veld. Themeda triandra occurred in both moderate and good veld conditions, but it was the 
only species in good veld. The two forb species occurred in all the treatments.

The aboveground botanical composition was positively correlated ($R^2 = 0.94; n = 80; P < 0.05$) with 
seed bank species composition. The density (plants/m²) of perennial species was significantly higher ($P < 
0.05$) in the good veld condition than in all the other sites on the degradation gradient. The density 
(plants/m²) of annual species on the poor veld condition site was significantly higher ($P < 0.05$) compared to 
bare soil and the good veld condition sites, but not significantly higher ($P > 0.05$) compared to the moderate 
veld condition site. Seed bank germination analysis along a veld condition degradation gradient is 
summarised in Figure 1.

![Figure 1: Seed bank germination analysis (plants/m²) of a veld condition degradation gradient (LSD<sub>0.05</sub> = 4.2; $r^2 = 0.94$)](http://www.sasas.co.za/sajas.html)
Conclusions
Replacement of plants depends to a great extent on the presence of viable seed in the soil seed bank. The decline in seedling density and changes in seedling species composition from the seed bank used for the degradation gradient could be attributed to the change in species composition and the lower plant density (plants/m²) that are observed as this vegetation type degrades from good to poor condition and eventually to bare soil. This research does not examine and clearly demonstrate the effects of the above mentioned factors on the seed bank, e.g., soil water content, seed production, erosion, etc., but it only shows the relation between veld condition and the size and composition of the seed bank. With an increase in grassland degradation the potential for recovery by means of viable seeds in the soil seed bank decreases. Thus, when disturbed, veld in poor condition does not have the potential to recover at the same rate as veld in good condition. Drastic management interventions, such as the introduction of fresh seed and soil manipulation, will be required for the restoration of poor condition veld for sustainable livestock production.

References