Paper ID: 751
**Theme 2.** Grassland production and utilization
**Sub-theme 2.7.** Seed production, storage, availability and quality

# Soil seed bank study on abandoned fields and semi-arid grassland, South Africa

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**Keywords:** Seed bank, abandoned fields, grassland, species richness

## Introduction

Up to the 1980's marginal soils in the central grasslands of South Africa were successfully ploughed for crop production, but unfortunately those soils soon proved to be uneconomical. Due to high input costs, low maize prices, and unreliable rainfall, the Department of Agriculture soon implemented the "soil conversion scheme" to promote the conversion of those ploughed marginal soils to permanent pastures. Regardless of the implementation the soil conversion scheme, many farmers unfortunately just abandoned some of these marginal fields, not establishing permanent pastures. This led to many hectares of unproductive previously cultivated fields, referred to as abandoned fields. It was noted that such abandoned fields do not recover to the same potential as the natural grassland of those areas. Therefore, it was decided to investigate a few such fields at a single location in a semi-arid climate of the Free State province, South Africa. The aim was to gain some knowledge on the dynamics of such disturbed ecosystems and identify the restoration potential of such situations. Amongst others, the soil seed bank was investigated to quantify the soil seed bank potential of abandoned fields, and why climax grass species do not establish voluntarily on these disturbed areas. The main aim was to quantify the differences in the soil seed bank between abandoned fields and natural grasslands, by investigating the research question: are there any climax grass species in the soil seed bank of abandoned fields available for grassland restoration?

## Materials and Methods

The farm where the study was conducted is located about 80 km north-east of the city of Bloemfontein in the semi-arid grassland of South Africa (28°55'36.69" S; 26°37'31.97" E, altitude 1 450 m). Rain falls almost exclusively during summer (October to April) and is unreliable and highly variable with a long-term annual mean of 525 mm and a mean of 66 rainy days per year. The mean maximum temperatures (29-year average) range from 31.2°C in January to 17.5°C in July, while the mean minimum varies from 15.3°C to -1.3°C (WB 42 2002). Frost occurs from the end of April to the beginning of October. The study area is situated in the Grassland Biome. This biome covers the largest part of the higher lying regions (Highveld) of central South Africa (Mucina and Rutherford, 2006).

The soil seed bank was determined to quantify the potential number of plant species available and seed bank size in the soil. The soil sampling was done in spring (September) and repeated in mid-summer (December). The first sampling can be seen as carrying over from the previous season (before new seed set) and the second as after the first seed production event of the current season (Snyman, 2013). With these results it is possible to determine seeds present in the soil and their role played in the poor distribution and occurrence of for example climax plants such as *Themeda triandra* (a dominant grass species in undisturbed areas) on abandoned fields.

Soil for the trial was collected from three adjacent abandoned fields (abandoned for 20 years) as well as adjacent natural grassland. Soil was randomly collected between plant species tufts in each quarter of a 10 m X 10 m block. Five such blocks were randomly distributed over each of the abandoned fields and the natural grassland. The soil was taken from the upper 50 mm of the A horizon. Soil samples were evenly spread (50 mm deep) in plastic buckets (2 L) containing a 50 mm layer of Hygrotech growth medium (Canadian peat, polystyrene vermiculite and mono-ammonium phosphate). The soil seed bank study was conducted in the greenhouse from September to May, 2012. The respective day and night temperatures were 32°C (±2 °C) and 18°C (±2 °C). The buckets were randomly placed in the greenhouse and hand-watered daily to keep the top soil layer moist. Seedling emergence was recorded daily and seedlings were removed after identification over the span of three months.

The effect of location on the percentage germinationwas analysed using a fully randomized one way ANOVA design. The PROC ANOVA procedures of the SAS program (SAS 2010) were used to test for significant differences between treatments. When significant differences were identified ($P \leq 0.05$) a further multiple comparison test, Tukey's honest significant difference (HSD) test, was used to identify these differences.

**Results and Discussion**

The number of climax grass seedlings that emerged from the grassland was significantly ($P < 0.05$) higher at 80 seedlings $m^{-2}$ (September) and 58 seedlings $m^{-2}$ (December) compared to only 33 seedlings $m^{-2}$ (September) and 20 seedlings $m^{-2}$ (December) for the abandoned fields (Table 1). For both locations the dominant climax grass species was *Themeda triandra*, the most common and also most important climax grass species of the region. No significant ($P > 0.05$) differences in number of sub-climax species were recorded between locations, with *Eragrostis chloromelas* the dominant species at both locations. Pioneer grass species by far showed the highest germination at the abandoned fields at 164 seedlings $m^{-2}$ (September) and 69 seedlings $m^{-2}$ (December) compared to only 11 seedlings $m^{-2}$ (both September and December) for the grassland (Table 1). These results were also reflected in looking at the species richness of both locations.

**Table 1:** Mean seed bank density (mean number of live seedlings m-2) from abandoned field (AF) and grassland (GL), grouped according to three succession stages. Total in the same columns with different superscripts, differ significantly ($P<0.05$)

| Grass species per succession stage | September | | December | |
|---|---|---|---|---|
| | AF | GL | AF | GL |
| **Climax** | | | | |
| *Cymbopogon pospischili* | 8 | | | |
| *Digitaria eriantha* | | 19 | | |
| *Heteropogon contortus* | | | 5 | 5 |
| *Paspalum dilatatum* | 6 | | | |
| *Themeda triandra* | 19 | 61 | 15 | 53 |
| **TOTAL** | $33^{b}$ | $80^{a}$ | $20^{b}$ | $58^{a}$ |
| **Sub-climax** | | | | |
| *Aristida bipartita* | 3 | | 1 | |
| *Eragrostis bicolor* | 2 | 6 | | |
| *Eragrostis chloromelas* | | 10 | 10 | 15 |
| *Eragrostis lehmanniana* | 7 | 2 | 2 | 6 |
| *Eragrostis plana* | | | 5 | |
| *Panicum stapfianum* | | 3 | | |
| **TOTAL** | $12^{a}$ | $21^{a}$ | $18^{a}$ | $21^{a}$ |
| **Pinoeer** | | | | |
| *Aristida congesta* | 31 | 11 | 15 | |
| *Brachiaria eruciformis* | 42 | | | 5 |
| *Chloris virgata* | 67 | | 14 | |
| *Cynodon dactylon* | 24 | | 40 | 6 |
| **TOTAL** | $164^{a}$ | $11^{b}$ | $69^{a}$ | $11^{b}$ |

On the abandoned fields, seedling emergence of the pioneer grasses was the highest at 74% species, while on the grassland that of the climax grasses was the highest at 68% (Figure1). These results indicate that the soil seed bank can be regarded as one of the reasons why abandoned fields do not recover to the same potential as undisturbed grasslands. The soil seed bank of abandoned fields is dominated by pioneer species, with only 17% seedlings of climax grass species. The same tendency was reported by Bekker *et al*., (1997) who found that previously cultivated fields reduce the heterogeneity of seed banks within the soil. On the contrary, the grassland soil seed bank is dominated by climax species (68%), with very little (11%) seed of pioneer species.

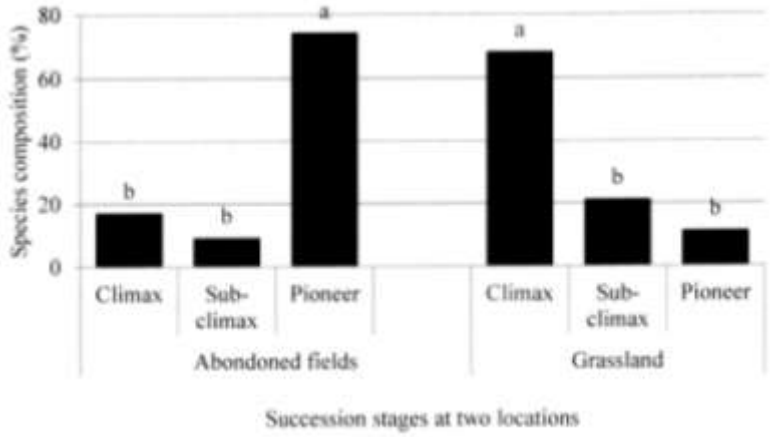


**Fig. 1:** Species composition (%) for the different succession stages for seedlings in abandoned fields and grassland. Different alphabet letters within location differ significantly.

**Conclusion**

This study sheds more insight on the poor natural rehabilitation rate of abandoned fields in semi-arid grasslands. It was proofed that the establishment of climax vegetation might be largely influenced by the composition of the soil seed bank. Drastic human interference by development and application of scientific management strategies is an absolute necessity to speed up the process of plant succession (rehabilitation). Future investigation might include long-term trials to monitor the vegetation and soil characteristic's reaction to the introduction of organic matter, as well as seed of climax grass species.

**References**

Bekker, R. M., G. L. Verweij, R. E. N. Smith, R. Reine, J. P. Bakker and S. Schneider. 1997. Soil seed banks in European grasslands: does land use affect regeneration perspective. *J. of Appl. Ecol.* 34: 1293–1310.

Mucina, L. and M. C. Rutherford. 2006. The vegetation of South Africa, Lesotho and Swaziland. *Stelitzia 19, Pretoria. South African National Biodiversity Institute (SANBI).*

SAS. 2010. Statistical Analysis System user's guide (version 9.3). Cary: SAS Institute.

Snyman, H. A. 2013. Disturbances impact on longevity of grass seeds, semi-arid South African rangeland. *Rangeland Ecol & Manage* 66: 143-156.