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Dormancy-breaking treatments in two potential forage crop legumes from the semi-arid rangelands of South Africa

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ABSTRACT

Native forages have been proposed as a plausible alternative to the use of exotic forage germplasm due to their adaptation to the surrounding bioclimatic and edaphic conditions, and the reduced risk of becoming weedy or invasive. *Calobota sericea* and *Lessertia frutescens* are two perennial legume species from the semi-arid rangelands of Namaqualand and are currently under investigation as fodder crops for use within these agro-ecosystems. These species display physical seed dormancy, and therefore, we aimed to investigate methods to break their dormancy to ensure fast and uniform seed germination and establishment. After collection, *C. sericea* and *L. frutescens* seeds were subjected to three dormancy breaking treatments, namely, mechanical scarification, boiling the seeds for 5 min, and placing the seeds in boiled water and leaving them until the water has cooled to room temperature. The seeds were thereafter germinated in petri-dishes. Mechanical scarification was the most effective method to break dormancy, and once the dormancy was removed, germination commenced rapidly. However, further research is needed to determine more efficient means to scarifying larger quantities of seeds.
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1. Introduction

In South Africa, the most extensive agricultural activity in water-limited agro-ecosystems is livestock farming under rangeland conditions. Here, livestock make use of the natural veld to meet their dietary requirements (Jordaan et al., 2013). These semi-arid rangelands are characterised by high rainfall variability, recurring droughts, extreme temperatures and marginal edaphic conditions (Palmer and Ainslie, 2006; Jordaan et al., 2013). During dry periods, livestock production within these rangelands declines due to a reduction in the availability and amount of good quality forages, resulting in summer feed gaps (Palmer and Ainslie, 2006). Under these marginal bioclimatic conditions, there are only a few commercially available forage species (*Atriplex nummularia* Lindl. and *Opuntia ficus-indica* (L.) Mill.) suitable for dryland fodder production (Dickinson et al., 2010; Truter et al., 2015). *Calobota sericea* (Thunb.) Boatwr. & B.-E. van Wyk and *Lessertia frutescens* (L.) subsp. *frutescens* Goldblatt & J.C. Manning are perennial legume species (Boatwright et al., 2009; Nkonki, 2013) that occur naturally within these rangelands, and therefore, are well adapted to these marginal bioclimatic and edaphic conditions. These species were observed to play an important role in livestock diets during the dry summer months in the Namaqualand region of South Africa (Samuels et al., 2016). Therefore, they have the potential to fill the summer feed gaps within the semi-arid rangelands in South Africa, and other areas experiencing similar bioclimatic conditions. However, their full potential still needs to be explored.

The seeds of *C. sericea* and *L. frutescens*, like many other legume species (Smýkal et al., 2014), display seed dormancy. Several dormancy classes have been identified, with rigorous reviews regarding the different forms of dormancy, and the evolution thereof by Finch-Savage and Leubner-Metzger (2006) and Willis et al. (2014), respectively. In the Fabaceae, the primary form of dormancy is physical dormancy imposed on the seed by an impermeable seed coat or testa (Smýkal et al., 2014). Generally, once the dormancy imposed by the seed coat is removed, seed germination can commence (Smýkal et al., 2014). Therefore, the present study was aimed at determining the most effective methods of breaking physical seed dormancy of *Calobota sericea* and *Lessertia frutescens*. The pre-germinating dormancy breaking treatments that were selected include those that use resources that are available to the resource poor communities where these species are intended to be used.

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2. Materials and methods

2.1. Experimental procedure

Physiologically mature seeds of *C. sericea* and *L. frutescens* were collected in November 2016 from naturally occurring populations within the Leliefontein communal area in the Northern Cape Province of South Africa. The communal area consists of 10 villages, and the seeds were collected from a minimum of 75 plants per sampling location from the rangelands surrounding the Leliefontein, Tweerivier, Spoegrivier and Kharkhams villages (Fig. 1). Seeds were removed from seed pods by hand to reduce mechanical scarification of the seeds. A total of 1000 seeds of each species (five replicates of 200 seeds for each species) were thereafter subjected to each of three dormancy-breaking treatments: mechanical scarification with an abrasive sandpaper, boiled for 5 min or placed in boiled water until cooled to room temperature. After applying the treatments, 50 seeds from each replicate, as well as five replicates of 50 seeds that did not undergo any of the dormancy breaking treatments (control), were immersed in 10 ml of dH_2O for 24 h at room temperature. After 24 h, the electrolyte leakage through the seed coats was determined by measuring the conductivity of the aqueous solution using a YSI benchtop conductivity meter (United Scientific (Pty) Ltd). A further 50 seeds from each replicate of each treatment and a control group, for each species were placed in glass petri-dishes on a layer of moist soil. The petri-dishes were placed in a growth chamber set to a 12/12-hour day/night and 25/18-°C temperature cycle. The seeds were watered as needed with dH_2O and germination was recorded every day for the duration of the experiment. Seeds with a radicle of 5 mm or longer were regarded as germinated and were removed from the petri-dishes. At the end of the trial, the percentage germinated, imbibed (seeds that were visibly swollen), dead and dormant seeds were determined. Those seeds that were dormant at the end of the trial were tested for their viability using a tetrazolium chloride test (Machlis and Torrey, 1956). From these seeds, those that were viable were regarded as dormant and non-viable seeds were considered dead. From this, the germination rate, calculated as the time taken to reach 50% of the final germination percentage (T_{50}), and germination uniformity, calculated as the time taken from 10% to 90% of the final germination percentage (T_{10}–T_{90}) were calculated following the equation of Farooq et al. (2004) only for treatments where more than 50% germination was achieved.

2.2. Statistical analyses

Data were statistically analysed using IBM SPSS Statistics for Windows Version 22.0 (IBM Corporation, Armonk, NY, USA). Electrolyte leakage data were log transformed while the percentage germinated, dormant, imbibed and dead seeds were ARCSINE transformed. Thereafter, a one-way analysis of variance (ANOVA) with a Tukey Post-Hoc test, performed separately for each species to determine whether the different pre-germination treatments influenced seed coat permeability and resulted in differences in the percentage of germinated, dormant, imbibed, and dead seeds. Transformed means were back-transformed for final illustrations.

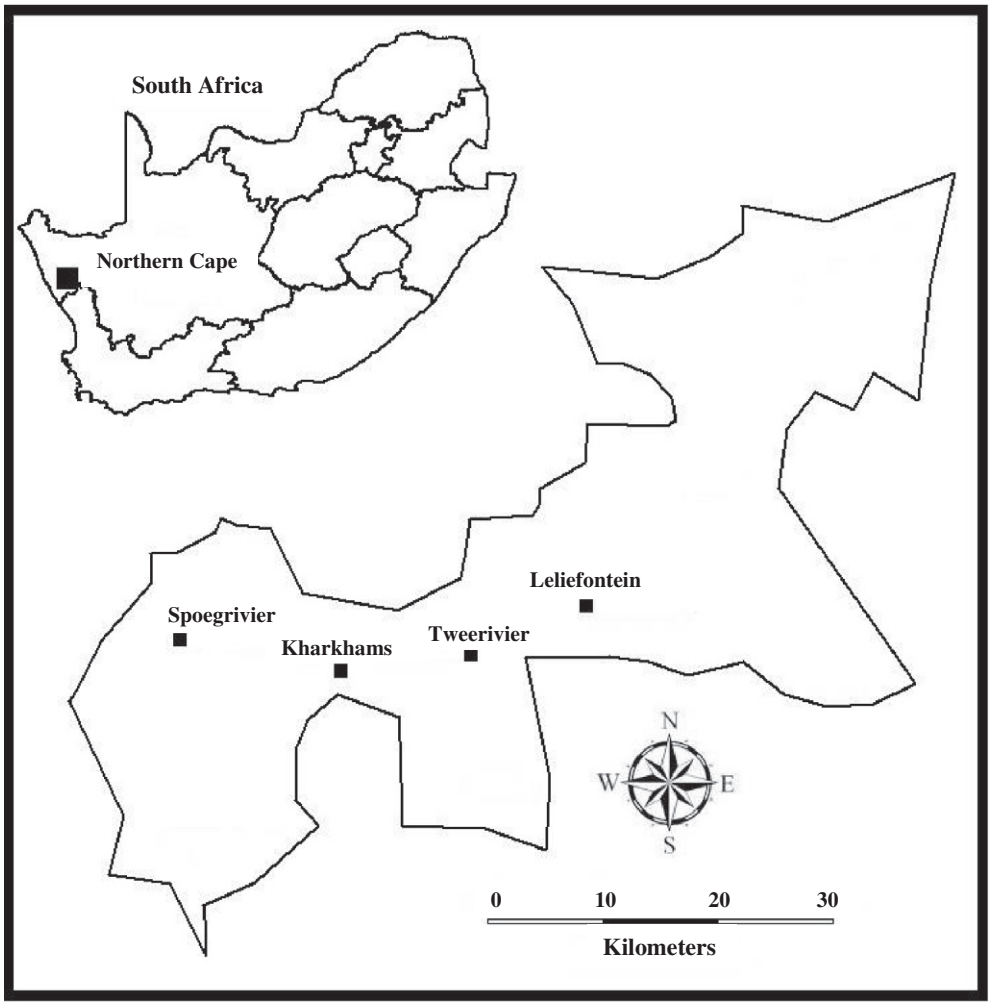

Fig. 1. Leliefontein Communal Area with four villages from where seeds were collected.

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