ABSTRACT

Observations of the changes in woody plant density in the Kruger National Park (KNP) over 58 years have shown an increase in large woody plant density on granite substrates, which is attributed to fire and herbivore density. Woody plants persist in areas with frequent fires, herbivory and drought by resprouting or protecting seeds in the ground. Soil seed banks, which are stores of seeds below ground or in leaf litter, provide 'insurance' for trees and allow populations to persist in unfavourable environments. No comprehensive studies have been conducted on soil seed bank ecology of *Acacia* species in the Kruger National Park, a research gap which this study aimed to fill.

The spatial distribution and density of *in situ* soil seed banks for four *Acacia* species, *A. grandicornuta*, *A. nilotica*, *A. senegal* and *A. tortilis* was assessed in the Skukuza land system of the KNP, South Africa. *In situ* soil seed banks were quantified for eight mature trees per species during 2005/2006. Greenhouse and field seed burial trials were carried out for one year and 16 months respectively, between 2005 and 2007, to investigate the persistence of *Acacia* seeds over an extended period of time. Post-dispersal seed predation of *Acacia* seeds was investigated during July 2006 in six demarcated grids within 15 km of Skukuza.

Overall soil seed bank density differed significantly among species, being highest for *A. tortilis* (19.5 ± 6.4 seeds m^{-2}), followed by *A. grandicornuta* (12.1 ± 6.9 seeds m^{-2}), *A. nilotica* (4.9 ±1.8 seeds m^{-2}) and lowest for *A. senegal* (0.6 seeds ± 0.4 seeds m^{-2}). Generally, seed bank density decreased with depth in the soil and distance from the centre of the tree canopy. Seed bank density increased significantly with a decrease in soil compaction for *A. senegal* only, while it was not related to over-storey canopy shading or herbaceous biomass for any of the species. No significant relationship was found between seed bank density and tree characteristics such as stem diameter, bark thickness or tree canopy area for any of the species. Viability of seeds from the seed bank decreased between species as follows: *A. tortilis* (77% of 142 seeds), *A. nilotica* (61% of 39 seeds), *A. grandicornuta* (58% of 87 seeds), and *A. senegal* (0% of 4 seeds). For all species with viable seeds, viability decreased with distance from the centre of the tree canopy. Bruchid beetle predation (assessed on 100 newly produced seeds) was low for all four species.

Fifty seeds each of *A. grandicornuta*, *A. senegal* and *A. tortilis* and 100 *A. nilotica* seeds were destroyed by fire during the field seed burial trial, of which four hundred seeds/species

were used. Of the remaining seeds, 15% of *A. senegal*, 19% of *A. grandicornuta*, 34% of *A. nilotica* and 66% of *A. tortilis* remained intact after 16 months in the field. Of these, 65% of *A. tortilis*, 27% of *A. nilotica*, 5% of *A. grandicornuta* and no *A. senegal* seeds were still viable. The percentage of remaining intact, viable seeds was highest under tree canopy cover and buried for *A. tortilis* (86%), *A. nilotica* (39%) and *A. grandicornuta* (6%), but the micro-site placement of seeds had a significant effect on viability for *A. nilotica* only (d.f. = l; $\chi^2 = 7.5$; $P = 0.006$).

In the greenhouse seed burial trial (150 seeds/species/treatment), one percent of the total seed lot germinated, which was 2.9% of *A. grandicornuta*, 0.7% of *A. senegal* and 0.2% of both *A. nilotica* and *A. tortilis*. *A. tortilis* had the highest percentage of remaining intact, viable seeds (92.2%), followed by *A. nilotica* (58.3%), *A. grandicornuta* (57.6%) and *A. senegal* (0%). The number of remaining intact, viable seeds was highest when watered with the average rainfall (327 seeds), followed by the highest (314 seeds) and lowest rainfall (296 seeds). There was no association between rainfall treatments and the number of remaining intact, viable seeds for any of the species, except for *A. grandicornuta* where the number of remaining intact, viable seeds increased significantly with the average rainfall.

Across six grids in the Skukuza land system, *A. grandicornuta* was the most dominant woody plant of six study species, followed by *Dichrostachys cinerea, A. tortilis, A. nilotica, A. senegal* and *A. nigrescens*. Woody plant density in grids varied between 226 plants ha^{-1} (Grid 3) to 1618 plants ha^{-1} (Grid 5), with a mean density of 862 ± 195 plants ha^{-1}. Overall, woody plant species diversity was low (Shannon Wiener Index, 1.8 ± 2.8; Evenness Index, 0.7 ± 0.02; Simpson's Reciprocal Index, 4.5 ± 0.6). The dung of nine species of large herbivore was recorded across all six grids. Large herbivores favoured seeds of indehiscent (55 *A. tortilis* seeds and 11 *A. nilotica* seeds) over dehiscent pods (1 *A. grandicornuta* seed). Only 9% (five *A. tortilis* seeds and one *A. grandicornuta* seed) of the 67 seeds extracted from dung germinated after a six-week germination trial. Less than half the remaining ungerminated *A. nilotica* seeds (46%) and *A. tortilis* seeds (40%) tested viable.

There was no correlation between the number of termitaria recorded and the number of *Acacia* trees growing on them ($r = 0.07$). Termite mounds occupied 0.0009 ± 0.0003 ha per grid matrix (0.8%).

Only four rodent species were recorded across all six grids, *Mastomys coucha*

(multimammate mouse), *Rhabdomys pumilio* (striped mouse), *Aethomys chrysophilus* (red veld rat) and *Tatera leucogaster* (highveld gerbil). Rodent species diversity was low (Shannon Wiener Index, 0.6 ± 0.2; Evenness Index, 0.6 ± 0.2; Simpson's Reciprocal Index, 1.9 ± 0.3). In the field cafeteria trial there was a significant difference in the percentage of seeds removed between seed species ($P < 0.05$; $F = 2.8$; d.f. = 3, 236). There was a significant difference in the percentage of seeds removed from trays placed under vegetation cover compared with trays placed in the open ($P = 0.034$).

This study suggests that *A. grandicornuta*, *A. nilotica* and *A. tortilis* seeds form short-term persistent seed banks, while *A. senegal* seeds are transient and do not form seed banks. Seeds of several woody plants were ingested by large herbivores and selected by rodents. The relevance of soil seed banks to regeneration of *Acacia* trees needs to be evaluated by investigating whether these species rely more on seed production or resprouting for individual recruitment into tree populations. Once this issue is clarified the effect of certain factors on seed fate and consequently, recruitment of individuals into plant populations, can be more clearly understood. This will assist in managing and understanding these potentially encroaching species in the Kruger National Park, South Africa.

KEYWORDS: *in situ* soil seed banks, persistence, germination, post-dispersal seed predation.

ABBREVIATIONS: KNP (Kruger National Park), NPNR (Nylsvley Provincial Nature Reserve), CSF (Corey Shape Factor), GI (Germination Index), PCQ (Point-Centred Quarter), GUD (Giving-Up Density), GPS (Global Positioning System), SE (Standard Error).