SEED FATE AND PRACTICAL GERMINATION METHODS FOR 46 PERENNIAL SPECIES THAT COLONIZE GOLD MINE TAILINGS AND ACID MINE DRAINAGE-POLLUTED SOILS IN THE GRASSLAND BIOME

I.M. Weiersbye and E.T.F. Witkowski
Restoration & Conservation Biology Research Group,
School of Animal, Plant & Environmental Sciences,
University of the Witwatersrand

Abstract

Indigenous perennial plants (woody, semi-woody and herbaceous re-sprouters) comprise the dominant naturally-colonizing and persistent flora of gold mine tailings and polluted soils in the grassland and savanna biomes. In order to determine which of these species had potential for the sustainable rehabilitation of gold mine tailings we characterized seed production, seed fate and patterns of seed dormancy and germination. This report lists seed fate and viability for 46 species (excluding annuals and grasses) common on gold slimes dams and the adjacent polluted soils, and practical germination methods for viable seed. Only data for plants growing on veld sites beyond the known influence of mine pollution is presented. All species examined produced viable seed. Most seed classed as non-viable or of low viability had been obviously predated or contained insect larvae. Seeds that had been predated or contained larvae were invariably also infected by fungi during germination, whereas few non-predated viable seeds and aborted seeds were infected. Two germination treatments killed endogenous insect larvae, and prevented or delayed seed-coat infection by fungi and bacteria in a dose-dependent fashion (smoke and transient incubation in hot water at 94°C). The viability status of untreated seeds could be directly related to trends in their dry mass and in the relative proportion of water they imbibed over 48 hours. The dry mass of seeds of all species increased from non-viable to high viability seeds, whereas untreated seeds of most species took up water in the trend of high viability<low viability<non-viable. The exceptions to this pattern of water uptake were untreated seeds of *Mundulea sericea* (no imbibition) and *Asclepias fruticosa* (viable seeds imbibed proportionately more water than non-viable seeds). Dormancy-breaking treatments that were assessed included removal of fruit tissues, seed scarification, long day light exposure, burial depth, exposure to water, aerated water, a reducing agent, organic matter, human saliva, fermentation, as well as dose responses to heat and plant-derived smoke. A number of germination indices were determined: mean days to germination, time of peak germination, duration of germination lag and time taken to achieve 50% germination. The majority of species could be germinated with relatively simple cues. Germination of all hard seed-coated legumes was achieved by mechanical disruption of the seed coat (by scarification or heat). Smaller legume seeds generally required longer exposure to heat than larger legume seeds. Germination percentages approaching or equaling 100% (of viable seeds) were achieved for most tree species, most shrubs and succulent forbs. Most perennial herbs and herbaceous resprouters had low levels of seed viability and germinability in comparison to trees, shrubs and forbs. Some treatments influenced the timing and rate of germination without necessarily resulting in changes in the overall percentage germination.

1. Introduction

Whereas individual plant establishment is dependent upon a variety of edaphic factors, long-term persistence of a species is dependent upon its regenerative capacity via seeds or re-sprouting from vegetative organs. There is little information on the regenerative characteristics of many indigenous plant species. Viable seeds of many species are however known to require complex sets of environmental cues in order to germinate (Baskin & Baskin, 1998). Our research group is focusing on the use of indigenous plant species for the sustainable rehabilitation of gold and uranium mine tailings, polluted soils and soils overlying contaminated aquifers, and for the restoration of riparian corridors after clearing of alien vegetation. The underlying assumption of this program is that the use of those indigenous plant species and ecotypes that are naturally colonizing the slimes (i.e. local land-races) will result in a higher probability of persistent cover, and thus persistent pollution containment (Weiersbye & Witkowski, 1998; Weiersbye *et al.*, 2002). Since this cover must require little maintenance and provide opportunities for natural rehabilitation to occur, plant populations must be established that can persist over the long term within a dynamic landscape and also include the ability to undergo selective evolution. The introduced plant land-races must therefore be genetically diverse, and have reasonable regenerative capacities, i.e. be able to set viable seed which will germinate and produce subsequent generations of individuals that are suited to growth in the particular environment. Because rehabilitation exercises usually establish relatively small populations, the amount of genetic variation represented in the founding population can be critical. Lack of genetic diversity within restored populations may accelerate their failure to persist, even in the short term.

To achieve the above aims large batches of seed from numerous species need to be germinated reliably, and the development of practical germination protocols are essential. Germination stimulants are diverse, often species-specific, can be modified by parental growth environment, and include physical and chemical treatments such as temperature stratification, chilling, changes in light chroma and/or day-length, fire (heat, smoke or organic acids), nitrate, hormone treatments, acidity or predation for digestion of germination inhibitors, scarification, percussion or accelerated aging to increase seed coat permeability, to name a few (de Lange & Boucher, 1990; Brown, 1993; Milberg *et al*., 1996; Keeley & Bond, 1997; Keeley & Fotheringham, 1997; 1998a; 1998b; Mbalo & Witkowski, 1997; Malakoff, 1997; Milberg & Lamont, 1997; Noronha *et al*., 1997; van Assche & van Nerum, 1997; Andersson & Milberg, 1998; Bell & Williams, 1998; Milberg & Andersson, 1998; Wilson & Witkowski, 1998; Baskin & Baskin, 1998 and references therein).

In order to determine which species and land-races had potential for the sustainable rehabilitation of gold mine tailings, we characterized seed fate and patterns of dormancy and germination in relation to growth substrate (i.e. on or off gold slimes dams and polluted substrata; Witkowski & Weiersbye, 1998). This report summarizes seed availability, pre-dispersal predation (by insects) and disease (caused by fungi and bacteria), seed shelf-life, levels of abortion, senescence and viability, seed germinability, practical germination cues and imbibition and germination rates for 46 perennial plant species growing on veld sites in the deep-level mining regions of South Africa, but beyond the known influence of mine pollution. Data for annuals and grasses, and for the effects of gold mining pollution on seed fate and germination will be reported elsewhere.

2. Methods

2.1 Seed collection

Ripe fruit were collected from woody and semi-woody species growing in the Klerksdorp, Welkom and Carletonville regions between January and August 1997 (Appendix I). Only fruit from a subset of plant species known to naturally colonize or persist on gold slimes dams was collected, and only from plants growing on veld sites beyond the influence of acid mine drainage (as gold mine pollution can impact negatively on plant seed production and viability; Weiersbye, 2002; Weiersbye & Witkowski, 2002). At least 50 fruit were collected from each of a minimum of five replicate individuals. Before removal of seeds most fruit were placed onto trays in a well-ventilated room for 8 weeks to complete any post-dispersal drying and seed maturation. Many seeds undergo post-dispersal maturation, and the seed biology of many of the species collected has not previously been studied in any great detail.

2.2 Seed fate

Seeds from 50 to 100 fruits per individual were categorized as either ‘predated’, ‘diseased’, ‘aborted’ or ‘intact’. Predated seeds had been partially or wholly eaten (leaving only the remains of the seed coat) by granivores, including the endogenous larvae of bruchid beetles, weevils and wasps. Diseased seeds were covered in fungi or bacteria. Aborted seeds were very under-developed relative to intact seeds. Intact seeds were ‘plump’ and apparently undamaged. However, during germination and viability testing a proportion of intact seeds were found to have latent endogenous predation or disease. In practice, it is often difficult to tell whether damage was caused by predation or disease, as predation often leads to the entry of disease, and thus these categories were often combined.

2.3 Seed mass

A sub-sample of 25 to 50 air-dry (ambient) and apparently intact seeds were randomly selected and weighed to a precision of 0.0001 g. Seed mass varies within and between species (Thompson *et al*., 1993; Garner & Witkowski, 1997) and with predation and abortion (Szentesi & Jermy, 1995; Garner & Witkowski, 1997). Thus seed mass is a useful index for assessing seed quality. The viability of weighed seeds (and thus mass of viable, poorly-viable and non-viable seeds) was subsequently determined for each sample and species.

2.4 Seed viability

Seed viability is commonly tested via germination. However, this can result in an under-estimation of viability for those species in which germination is less than optimal due to a lack of knowledge regarding appropriate conditions. It is therefore more accurate to use a vital stain for respiration on seeds. A subsample of 100 to 1000 seeds from each individual was tested for viability using the tetrazolium-chloride (INT) staining test that is routinely used for seed testing (Moore, 1985; Mbalo & Witkowski, 1997). The time needed for the stain to develop depends on embryonic respiration rates, seed size and tissue density, and varied from about 5 hours to 72 hours (data not shown). Three viability categories resulted from vital testing: namely (1) viable, (2) semi-viable and (3) non-viable. Semi-viable seeds had poorly stained embryos and in some cases obvious damage; in less than ideal environments, semi-viable seeds are functionally non-viable. The same seed batches from selected species were tested for viability and germinability when fresh (within a month of harvest),

6, 12, 24 and 48 months after harvest in order to establish shelf-life and identify any requirement for post-dispersal maturation. In addition to pre-treatment viability of seed batches, post-treatment viability was also established for those seeds that did not germinate during each treatment in order to establish whether the treatment lacked effectiveness in breaking dormancy or was lethal.

2.5 Seed imbibition rates

The ability of untreated seeds to imbibe water was assessed for 17 selected species. Twenty-five randomly selected and pre-weighed intact seeds per species were placed individually into separate wells (in pyrex `repli-dishes') on moistened ash-free filter paper. Seeds were incubated for 48 hours under a 14 hours Light, 10 hours Dark photoperiod, and seed mass then re-determined. These data give a good indication of whether seeds can imbibe moisture in their current state, or whether they have a hard impermeable seed coat. Seeds with a hard seed coat require some form of breakage of the seed coat to allow moisture to enter the seed. The rates of imbibition for treated and untreated seeds were determined by re-weighing the same seeds several times over a 12 to 144 hour period (time depending on the rate of moisture uptake). Total % imbibition of viable seeds was recorded, in addition to the mean number of days taken for imbibition, and the peak value for imbibition (i.e. the day upon which most species imbibed). The effects of additional treatments on seed germination were not assessed for species whose seeds germinated *en masse* subsequent to this imbibition pilot trial.

2.6 Seed germination cues and incubation

Practical germination cues were determined. Fourteen replicates for each species (comprising batches of 25 to 1000 seeds from each of fourteen individuals) were subjected to each treatment. Treatments are indicated by codes (A, B, C etc, see Appendix II for key) in the tables and text. Individual large seeds, and batches of small seeds, were incubated on the various media in separate wells of Pyrex replidishes to reduce interference by germinating conspecifics. Seeds were not surface sterilized prior to treatment, but seeds that exhibited disease during germination were removed and assessed for the presence of endogenous insect larvae. All replicates were randomized and incubated in controlled environment chambers, with a constant flow of fresh air circulated at a temperature of 30°C (Moore, 1985). Replidishes were moved randomly to new positions in the incubator every 24 hours. Light was provided at an intensity of 702±63 μmol/m/s by Fluora 77 Plant Growth Lighting tubes and incandescent lamps (Osram). This light spectrum is enriched in UV-A, blue and red to far-red chroma, and is deficient in green and yellow to orange chroma.

2.7 Seed germination rates

Total % germination of viable seeds was recorded, in addition to the mean number of days taken for germination, the peak value for germination (i.e. the day upon which most species germinated), the germination lag (i.e. days prior to onset of germination) and the t_{50} germination (i.e. the number of days it took for 50% of the total number of germinants to emerge). Germination was taken to be the time at which the emergent radicle measured at least 1 mm. Replicate batches of seeds were harvested at 14, 22 and 45 days after the start of incubation and the viability status of seeds that had not imbibed subsequent to treatment, or that had imbibed but not germinated was assessed.

2.8 Seed shelf-life

The seed of selected species were assessed for viability and germination response to treatments when their seeds were freshly harvested, up to 6 months later, and again between 9 and 24 months later in order to identify any necessity for post-maturation drying, and establish seed shelf-life and changes in germination responses with age.

3. Results

Data are presented as means ± standard errors in Tables 1 to 4. Table 1 summarizes seed fate for each species. Table 2 describes seed viability in relation to seed mass and imbibition. Table 3 summarizes treatment and seed age class effects on the overall germination of each species, whereas Table 4 describes the same effects upon the progress of seed imbibition and germination.

3.1 Pre-dispersal seed fate

The numbers of intact seeds/fruit ranged greatly between species (Table 1). The percentage of intact seeds varied from close to 100% in *A. naudiniana, A. harveyanus, C. brachiata, C. monticola, C. sessilifolia, D. herbeum, E. elephantina, L. elonuris, M. burkeana, N. hottentottica, N. rarifolia, R. lancea, R. pyroides, S. verbenaceae, S. incanum* and *S. frutescens* to around 30% in *A. erioloba, A. hebeclada, A. hereroensis, M. sericea* and *T. sonderi*. Seed abortion varied from apparently 0% to 100%, but was generally a low percentage for most species. Levels of seed predation tended to

be higher than that of seed abortion, although late abortion in some seeds could have been a consequence of predation (Table 1). The % of viable seeds was lower than % intact seeds, except for *A. laricinus, C. monticola, C. myriocarpus, D. whyteana, E. elephantina, M. burkeana* and *S. frutescens,* where virtually all intact seeds were devoid of latent defects and were viable. Seed intactness was generally a poor indicator of viability for the herbaceous perennials and resprouters.

3.2 Seed dry mass and the imbibition of water by untreated seeds

Dry mass per seed was always greater for viable relative to non-viable seeds, with low-viability seeds tending to show intermediate values. The imbibition (percentage moisture uptake) of most untreated seeds increased in the order viable < semi-viable < non-viable seeds (Table 2). These data corroborate the vital stain viability data by indicating the viability-status of seeds using seed mass and seed moisture uptake as physical measures. The only exceptions to this pattern of water uptake were untreated seeds of *Mundulea sericea* (no uptake at all) and *Asclepias fruticosa* (viable seeds imbibed proportionately more water over 48 hours than non-viable seeds).

3.3 Seed fate, viability, germination and shelf-life for each species (see Appendix II for Key to Treatment Codes; (codes are stipulated in brackets, e.g. B)

3.3.1 *Acacia erioloba* (tree)

Seeds were produced in large numbers but only around 30% of seeds were intact due to predation. Post-harvest, ~ 50% of intact seeds had latent defects due to bruchid larvae. Once latent defects were taken into consideration, ~22% of the intact seeds were viable (9% in total). The seeds of this species are hard-coated and did not decline in viability or germinability with age up to 2 years when stored dry at 4°C (the low temperature inhibited bruchid larval development), and 1 year at room temperature. The seeds exhibit hard seed-coated dormancy, which must be broken by scarification (B) or exposure to elevated temperatures (L, M & N). The seeds do not have a strong light requirement for germination, indicating that seeds can be buried. Maximum germination (100%) was obtained by scarification (B) or hot water treatment (L), prior to exposure to a long day (Table 3). Rates of imbibition and germination are rapid with fastest germination occurring when seeds are scarified (B) prior to exposure to a long day: 3 days to start, with 50% of seeds having germinated by 6 days (Table 4).

3.3.2 *Acacia hebeclada* (tree)

Seeds were produced in large numbers but only 29-38% of seeds were intact when fresh (Table 1), declining to ~20% after 6 months due to predation in storage. Post-harvest, ~30-59% of intact seeds had latent defects due to bruchid larvae. Once latent defects were taken into consideration, ~41-70% of the intact seeds were viable. The seeds of this species are hard-coated and did not decline in viability or germinability with age up to 1 year when stored dry. Although when harvested from immature pods these seeds germinate readily, mature seeds exhibit hard coated dormancy, which must be broken by scarification (B) or exposure to hot water (M) (Table 3). The seeds do not have a strong light requirement for germination, indicating that seeds can be buried. Maximum germination (100%) was obtained by scarification (B), prior to exposure to a long day (14 hours of light). Seeds responded to smoke after 20 minutes exposure (G). Longer exposure to smoke was lethal. Pretreatment with boiling for up to 2 minutes (L, M & N) promoted some germination, whereas 5 minutes was lethal, indicating that an intermediate period of heat would probably be optimal (Table 3). Fresh seeds from immature pods germinate slower than older seeds post-treatment, possibly indicating a post-shedding maturation requirement (Table 4). Rates of imbibition and germination are generally rapid with fastest germination occurring when both fresh and older seeds are scarified (B & I) prior to exposure to a long day: 1 day to start, with 50% of seeds having germinated by 5 days and most germinating on the 5th day after planting (for dormant seeds); 11 days to start, with 50% of germinants by 11 days (for fresh seeds) (Table 4).

3.3.3 *Acacia hereroensis* (tree)

Seeds were produced in large numbers but only 25% of fresh seeds were intact. Post-harvest, ~20-68% of intact seeds had latent defects due to bruchid larvae. Once latent defects were taken into consideration, ~33-80% of the intact seeds were viable (Table 1). The seeds of this species are hard-coated and did not decline in viability or germinability with storage up to 1 year when stored dry. Despite having a hard testa the seeds did not exhibit hard coated dormancy and did not have a light requirement for germination, indicating that seeds do not require a pretreatment to break dormancy and prefer burial or deep shade. Maximum germination was obtained (100%) by moist incubation both in entire darkness (A), and in the light (E: 92% germination) (Table 3). This species is

largely indifferent to smoke, which starts to prove lethal by 40 minutes of exposure, and does not require an elevated temperature treatment in order to germinate. Fresh seeds germinate faster than older seeds (Table 4), and the difference may be due simply to the higher water content of young seeds and absence of a requirement for post-maturation drying. Rates of imbibition and germination are rapid, with fastest germination occurring for seeds in the dark (A, i.e. buried): 3 days to start, with 50% of germinants by 4 days. Germination in the light (E, i.e. not buried, or shallow-burial) is two-thirds slower, but 100% of seeds do still germinate (Table 4).

3.3.4 *Acacia karroo* (tree)

Seeds were produced in large numbers and 81-87% of seeds were intact. Post-harvest, ~0-28% of intact seeds had latent defects due to bruchid larvae. Once latent defects were taken into consideration, ~73-100% of the intact seeds were viable (Table 1). The seeds of this species are hard-coated and did not decline in viability or germinability with age up to 1 year when stored dry. Seeds harvested from immature pods germinate rapidly in the presence of moisture without pretreatment but have a slight light requirement (indicating shallow burial), whereas mature seeds exhibit hard coated dormancy which must be broken by scarification or hot water treatment for 1 to 2 minutes. Maximum germination was obtained (100%) by scarification (B & I), followed by long-day incubation and shallow burial (Table 3). Although promoted by heat and short-term smoke exposure, the germination of this species is inhibited by longer term exposure to smoke, which starts to prove lethal by 40 minutes of exposure. The seeds germinate faster in the light than in the dark (Table 4). Shallow burial of 2 to 5 mm ensured that seeds both germinated and germinants emerged. Fresh seeds germinate slightly faster than older seeds. Rates of imbibition and germination are rapid with fastest germination occurring for fresh seeds during exposure to a long day photoperiod and shallow burial (D): 1 day to start, with 50% of germinants by 4 days. For older seeds, most rapid germination occurs after either scarification (I) or 2 minutes at 94°C (N) followed by exposure to a long day photoperiod and shallow burial: ~3 days to start, with 50% of seeds germinated by 7 days (Table 4).

3.3.5 *Acacia robusta* (tree)

Seed biology is similar to *A. hebeclada*. Seeds were produced in large numbers and around 85% of seeds were intact. Post-harvest, some intact seeds had latent defects due to bruchid larvae (Table 1). Seeds have hard seed coated dormancy that was broken by scarification (B), or stratified hot water treatments for a total of 3 minutes (O). Seeds can be buried at not <10mm. Maximum germination was obtained (100%) by stratified hot water treatment (O), prior to burial and exposure to a long day (14 hours of light), with germination starting ~2 days after planting (Table 4). Under natural conditions high soil surface temperatures of 50°C (day) alternated with cooler nights result in the highest % germination (Mbalo & Witkowski, 2002).

3.3.6 *Acanthosiscyos naudiniana (creeper).*

Seeds were produced in large numbers and 92-93% of seeds were intact. Post-harvest, ~29-38% of intact seeds had latent defects. Once latent defects were taken into consideration, ~62-71% of the intact seeds were viable (Table 1). The seeds of this species are deeply dormant and germination was not achieved during this study. Germination was subsequently achieved with prolonged incubation at high temperature (approaching 60°C), red:far red light treatments and long day incubation (data not shown). The seeds of this species do not decline in viability with age for up to 3 years when stored dry, but die within 1 month when stored in damp conditions. Pre-treatments such as seed scarification, and incubation in hot water of 94°C are lethal.

3.3.7 *Asclepias fruticosa* (forb)

Seeds were produced in large numbers. Around ~25-50% were intact. Post-harvest, ~38-84% have latent defects. However, after latent defects were taken into consideration, ~16-61% of intact seeds were viable (Table 1). The seeds of this species did not exhibit a decline in viability and germinability with age up to 1 year when stored dry. However, when seeds were stored in damp conditions viability declined rapidly to zero within 1 month. Seeds do not exhibit dormancy, and have a light requirement for germination, indicating that deep burial would be inhibitory. Maximum germination was obtained for seeds (100%) by simple exposure to a 14 hour day (D & E,), and by smoke exposure for 10 minutes (F) (Table 3). Brief smoke exposure also had the advantage of inhibiting fungal diseases. Exposing imbibed seeds to extended periods of dark (and smoke) proved lethal and therefore this species is not tolerant of deep burial. Imbibition and germination was rapid (Table 4). Although this species simply requires exposure to light (long days) in order to germinate, a 10 minute smoke exposure (F) prior to exposure to light (i.e. shallow burial) facilitates the most rapid germination: 3 days to start, with 50% of germinants by 6 days and most germinating on the 9 day after planting.

3.3.8 *Asparagus laricinus* (forb)

Around 80% of seeds were intact. Post-harvest, ~0-4% of intact seeds had latent defects. Once latent defects were taken into consideration, ~96-100% of the intact seeds were viable (Table 1). The seeds of this species exhibited a slight decline in viability (but not in germinability) with age up to 1 year, but were not adversely affected by damp, dark storage for 1 month. This species does not have a light requirement for germination (A), although germination rate is greatly enhanced in the presence of light (E). Seeds do not require a pretreatment in order to accomplish 100% germination (E) (Table 3). This species exhibits consistently high % germination, of a moderate speed: 12 days to start, with 50% of germinants by 18 days (E) (Table 4).

3.3.9 *Aster harveyanus* (resprouter)

Around 92% of seeds were intact, with ~30% having latent defects and 70% viable (Table 1). Seeds had a strong light requirement for germination. Optimal germination (69%) was achieved by exposure to light under a long day photoperiod (D; Table 3). Germination was relatively uniform (Table 4): 5 days to start with 50% of germinants on the same day.

3.3.10 *Berkheya setifera* (resprouter)

100% of seeds were usually intact, with ~86% having latent defects and only 15% viable (Table 1). The seeds did not germinate in the only treatments attempted (A and D).

3.3.11 *Carpobrotus edulis* (succulent ground-cover)

All seeds (100%) were intact, with ~54% being viable (Table 1). All (100%) of viable seeds germinated on exposure to light (E) (Table 3). Germination started 5 days after planting, with 50% of germinants by 10 days (Table 4).

3.3.12 *Clematis brachiata* (climber)

Seeds were produced in large numbers with 100% of seeds intact. However, post-harvest, up to 41% had latent defects. After latent defects were taken into consideration, ~60-100% of intact seeds were viable (Table 1). The seeds of this species did not exhibit a decline in viability with age up to 1 year when stored dry, nor when stored in damp dark conditions for 1 month. Seeds have a strong light requirement for germination, indicating that deep burial would be inhibitory. Maximum germination was obtained (75%) by exposure to a long (14 hour) day (D) (Table 3). Imbibition and germination were slow (Table 4): 15 days to start, with 50% of germinants by 33 days.

3.3.13 *Clutia monticola* (shrub)

100% of seeds were intact. Post-harvest, ~23% had latent defects and ~77% of intact seeds were viable. Despite high viability, only 30% of viable seeds could be germinated (with germination starting at 3 days) by a potentially lethal treatment, and therefore germination of this species needs to be optimized (Tables 3 & 4).

3.3.14 *Coccinia sessilifolia* (climber)

Around 100% of seeds were intact. However, post-harvest, ~20% had latent defects. After latent defects were taken into consideration, ~80% of intact seeds were viable (Table 1). The seeds of this species exhibit a decline in viability with age after 9 months dry storage, and no decline in viability after storage in damp dark conditions for 1 month. Seeds could not be germinated with any of treatments A, C, D and E. It was later found that maximum germination was obtained for seeds by exposure to 10-20 minutes of smoke or red:far red light treatments, followed by shallow burial and exposure to a long (14 hour) day.

3.3.15 *Cucumis myriocarpus* (creeper)

Around 85% of seeds were intact. Post-harvest, ~ 36-39% had latent defects. After latent defects were taken into consideration, ~ 61-67% of intact seeds were viable (Table 1). The seeds of this species exhibit a decline in viability with age after 6 months dry storage, and no decline in viability after storage in damp dark conditions for 1 month. Only ~12% of viable seeds germinated (A; Table 3), after a period of 4 days (Table 4). Subsequent experiments demonstrated that in common with other cucurbits, seeds of this species respond to changes in red:far red light and 100% germination was achieved (data not shown).

3.3.16 *Delosperma herbeum* (succulent forb)

All (100%) of the seeds were intact, with ~48% having latent defects and therefore ~52% viability (Table 1). Seeds had a light requirement for germination (D), and were quick to germinate: 100% germinated, with germination starting *en masse* 10 days after planting and with 50% of germinants on the same day (Table 3 & 4).

3.3.17 *Diospyros lycioides* (shrub)

Around 85-88% of seeds were intact. Post-harvest, ~2-25% of intact seeds had latent defects. Once latent defects were taken into consideration, ~75-98% of the intact seeds were viable (Table 1). The seed testa of this species is extremely thick and dense and seeds did not decline in viability or germinability with age up to 2 years, nor with damp dark storage for 1 month. The seeds have a light requirement for germination (E). Germination percentage was roughly doubled after storage of seeds for 1 year, indicating a long after-ripening requirement by this species. Seeds do not require a pretreatment in order to germinate (E: 88%), and 10 mins smoke exposure, scarification and 30 seconds of boiling only slightly enhance percentage germination (92%, 100% and 96% respectively) (Table 3). Fresh seeds germinate slightly faster than older seeds (Table 4), although a higher percentage germination is achieved if the seeds are allowed to after-ripen. Although this species exhibits consistently high % germination, rates of imbibition and germination are extremely slow. Germination rates are slightly improved if seeds are scarified prior to shallow burial and exposure to a long day (B & I): ~9 days to start, with 50% of seeds germinated by 25 days. The germination rate in sand without pre-treatment was ~25 days to start with 50% of germinants by 38 days after planting.

3.3.18 *Diospyros whyteana* (tree)

Around 80% of seeds were intact. Post-harvest, ~15% of intact seeds had latent defects. Once latent defects were taken into consideration, ~85% of the intact seeds were viable (Table 1). The seed testa of this species is extremely thick and dense and seeds did not decline in viability or germinability with age up to 2 years. The seeds have a light requirement for germination, and therefore should not be buried too deeply. Seeds do not require a pretreatment in order to germinate (E: 100%) (Table 3). Rates of imbibition and germination are extremely slow (Table 4): ~20 days to start, with 50% of seeds germinated by 30 days.

3.3.19 *Elephantorrhiza elephantina (*underground tree)

Seeds were produced *en masse* by plants only once in a six-year period. Up to 97% of seeds were intact and viable. Non-viable seeds had been partially eaten by rodents. No bruchid larvae were found associated with the seeds of this legume. All (100%) of intact seeds germinated uniformly and rapidly after either scarification (B) or hot water treatment for 30 seconds (L) (Table 3). Germination was rapid: *en masse* on day 4 to 7 (Table 4). All seeds had germinated by 7 days. Untreated seeds also geminated, but at a much slower rate.

3.3.20 *Euclea crispa* (tree)

Around 87% of seeds were intact. Post-harvest, between 0 and 76% had latent defects and viable seed production ranged therefore from 24 to 100% with batch. Despite the high viability, seeds would not germinate simply on exposure to dark or light (A & D), or in tetrazolium (C). Other treatments were not assessed.

3.3.21 *Gazania krebsiana* ssp. *serrulata* (herbaceous perennial groundcover)

This species flowered abundantly but did not produce any viable seed.

3.3.22 *Grewia flava* (shrub)

Around 61% of seeds were intact, with 29% being viable (Table 1). Only 5% of seeds germinated in the dark (A), and none in the light (D). However, 100% germination (of viable seeds) was achieved in tetrazolium (C) (Table 3), although these seeds subsequently died. This species is bird-dispersed and although germination percentages in this study were poor (with the exception of C), we observed seeds germinating in bird faeces around *Grewia* bushes.

3.3.23 *Gymnosporia polyacantha* (tree)

Seeds were produced in large numbers, with ~85% of seeds intact. However, post-harvest ~73% of seeds had latent defects. After latent defects were taken into consideration, ~28-68% of intact seeds were viable (Table 1). The seeds of this species exhibited no decline in viability after storage in damp dark conditions for 1 month. Longer storage, whether wet or dry, resulted in seed dehydration and death. Despite high viability, few seeds would germinate and the highest % germination (~12%) was obtained after exposure to light and a long day photoperiod (E) (Table 3). This species was relatively indifferent to smoke exposure of 10 and 20 minutes (F & G), which slightly delayed germination, whereas 40 minutes of smoke exposure (H), and hot water treatments (L-P) proved lethal (Table 4).

3.3.24 *Helichrysum nudifolium* (resprouter)

Around 38% of seeds were intact, of which only 60% were viable (Table 1). 33% of seeds germinated in the only treatment attempted (D) (Table 3).

3.3.25 *Helichrysum rugulosum* (resprouter)

Only 58% of seeds were intact due to predation. Of the intact seeds, only 21% were viable (Table 1). After 1 year in storage seed viability had declined by half. Seeds imbibed readily but only 19% of viable seeds germinated on exposure to light (D) (Table 3).

3.3.26 *Indigofera adenoides* (forb)

Around ~86-90% of seeds were intact, with ~48-84% of these intact seeds having latent defects. After latent defects were taken into consideration, ~16-52% of intact seeds were viable (Table 1). The seeds of this species did not exhibit a decline in viability when stored in damp dark conditions for 1 month. Seeds did not have a strong light requirement for germination (A, D), and germination rate was in fact slowed by exposure to light. Highest % germination (~68%) was achieved without pretreatment (A, D). A higher % germination (100%) was achieved, but this was in tetrazolium which subsequently proves lethal (C) (Table 3). Imbibition and germination were rapid in the dark (A): 2 days to start, with 50% of germinants achieved by 4 days; and slower in the light (D): 8 days to start and 50% of germinants achieved by 35 days (Table 4).

3.3.27 *Leonotis leonurus* (forb)

Around 78 to 99% of seeds were intact. Of these, ~88% were viable. Seeds did not lose viability after dry storage for 1 year. All seeds germinated on exposure to light (D) (Table 3). Germination was rapid and uniform (Table 4): 4 days to start, with 50% of germinants by 6 days (Table 4).

3.3.28 *Lippia scaberimma* (forb)

Around 50-86% of the seeds were intact, with ~51-90% having latent defects and therefore ~10-50% viability (Table 1). Seeds lose viability rapidly – both in dry storage and in damp storage and therefore must be planted within 6 months after harvesting. Seeds did not have a strong light requirement for germination. However exposure to light greatly speeded germination. Highest germination (40%) was obtained upon exposure to light with a long-day photoperiod (D) (Table 3), with germination peaking at 3 days after planting (Table 4).

3.3.29 *Lophalaena coriifolia* (shrub)

Between 67 and 98% of seeds were intact and viable (Table 1). Viable seeds could be distinguished from nonviable seeds as during imbibition the former without exception developed a gelatinous hydrated capsule. All

(100%) of viable seeds germinated in the light (D), whereas none germinated in the dark (A). Seeds germinated rapidly and uniformly: 5 days to start with 50% of germinants by 8 days.

3.3.30 *Monsonia burkeana* (resprouter)

All (100%) of the seeds were intact, with ~92% having latent defects and therefore only ~8% viability (Table 1). Seeds would not germinate simply on exposure to light, but 100% of viable seeds germinated during viability testing with tetrazolium chloride (Tables 3 & 4). However, this treatment was lethal.

3.3.31 *Mundulea sericea* (tree)

Around 35% of seeds were intact. Post-harvest, no seeds had latent defects and therefore 100% of intact seeds were viable. Seeds have a hard seed coat that must be rendered permeable to water to break dormancy. This is best achieved by scarification, or stratified hot water treatments (O). Seeds have a light requirement for germination and therefore require shallow burial. Maximum germination was obtained (100%) by stratified hot water treatments (O), prior to shallow burial and exposure to a long day photoperiod (Table 3), with germination starting ~3 days after pretreatment. If not pretreated, 26% of seeds still germinated, although germination was much slower (D & E): 15 days to start, with 50% of germinants by 20 days (Table 4).

3.3.32 *Nidorella hottentottica* (resprouter)

100% of seeds were intact but none were viable (Table 1).

3.3.33 *Nolletia rarifolia* (resprouter)

100% of seeds were intact but only ~12% were viable (Table 1). The seeds would not germinate in the only treatments attempted (A and D).

3.3.34 *Pollichia campestris* (forb)

Around 100% of seeds were intact. Post-harvest, 24-69% of seeds had latent defects and ~31-76% of intact seeds were viable(Table 1). The seeds of this species exhibited a slight decline in viability and germinability with age up to one year when stored dry. Although the highest % germination was obtained with a treatment that inhibits post-germination growth (80-100% in C1 & R tetrazolium chloride treatments), 65% germination of seeds was obtained simply by exposure to light (Table 3). In the non-lethal treatments it took 16 days to *en masse* germination (Table 4).

3.3.35 *Rhus lancea* (tree)

Around 97% of seeds were intact. Post-harvest, ~24-60% of intact seeds had latent defects and ~40-76% of the intact seeds were viable (Table 1). Seeds did not decline in viability or germinability with age up to 1 year, whereas the actual % germination and germination rate increased after seed storage and after-ripening for 9 months. The seeds have a light requirement for germination. Seeds do not require a pretreatment in order to germinate in the light (E: 74%), and are largely indifferent to smoke: 10 – 20 minutes smoke exposure (F & G) slightly enhanced % germination (82% & 91% respectively), whereas 40 minutes smoke exposure (H) slightly decreased % germination (68%). All hot water treatments were lethal (L-P) (Table 3). Older seeds germinate faster than freshly shed seeds: 6 days to start, with 50% germinants achieved by 12 days (E) (Table 4). Subsequent experiments have shown that seeds germinate more rapidly and uniformly (*en masse* by 8 days) if they are first fermented for 48 hours at 40°C, or exposed to human saliva for ~60 seconds by gentle chewing (data not shown).

3.3.36 *Rhus pyroides* (shrub)

Around 81 to 99% of seeds were intact. Post-harvest, 17 to 57% of seeds had latent defects and 43 to 83% were viable (Table 1). The seeds did not germinate under any of the treatments. However, subsequent experiments have shown that seeds germinate if they are first fermented for 48 hours at 40°C, or exposed to saliva for ~60 seconds by gentle chewing (data not shown).

3.3.37 *Salvia verbenacea* (forb)

All (100%) of seeds were intact, with ~80% being viable (Table 1). Seeds did not lose viability after 1 year in storage and were deeply dormant. Seeds did not imbibe or germinate in the two treatments attempted (C1 and D).

3.3.38 *Senecio scitus* (resprouter)

Around 44% of seeds were intact, and only 50% of these were viable (Table 1). Seeds maintained viability for 1 year in dry storage. The seeds would not imbibe or germinate in the treatment attempted (D).

3.3.39 *Solanum incanum* (shrublet)

Around 86% of seeds were intact. Post-harvest, up to 19% of seeds had latent defects and between 82 and 100% were viable (Table 1). The seeds did not decline in viability up to 1 year in dry storage, or 1 month in damp storage. Seeds were deeply dormant, with imbibition and germination only achieved by treatments which are lethal (C and R) (Table 3). Once dormancy was broken, imbibition and germination was rapid, peaking by 2 days (Table 4).

3.3.40 *Stoebe vulgaris* (forb)

60% of seeds were intact, with ~55% of these intact seeds having latent defects and ~45% of intact seeds being viable (Table 1). Seeds lost 80% viability after 1 year in dry storage. Seeds germinated (68%) rapidly on exposure to light (D).

3.3.41 *Sutherlandia frutescens* (forb)

Most (87 to 100%) of seeds were intact and all intact seeds were viable. Seeds did not lose viability with 2 years in dry storage. All seeds germinated subsequent to a hot water treatment for 30 or 60 seconds (L and M). Seeds started germinating after 3 days, with 50% of germinants by 7 days and 100% by 22 days (M).

3.3.42 *Triumfetta sonderi* (forb)

Around ~29% of seeds were intact. Post-harvest, ~57-58% of seeds had latent defects and ~42-43% of intact seeds were viable (Table 1). The seeds of this species did not exhibit a decline in viability when stored in damp dark conditions for 1 month. Seeds have a strong light requirement, and 20% of seeds germinated simply on exposure to light (D) (Table 3). Once dormancy was broken, imbibition and germination was very slow but uniform with germination starting at 30 days after planting, and 50% germinants achieved on the same day (Table 4).

3.3.43 *Ziziphus mucronata* (tree)

Around 61-75% of seeds were intact. Post-harvest, ~0-29% of intact seeds had latent defects and ~71-100% of the intact seeds were viable (Table 1). The seeds of this species did not decline in viability, and improved in germinability with age up to 1 year (in dry storage) provided they were left in the nutlets. Seeds died within 1 month if storage conditions were damp. The seeds have a light requirement for germination (A, E). Seeds do not require a pretreatment in order to germinate (E: 100%), and % germination is not affected by smoke of 10-40 minutes exposure (F-H), brief scarification (I) or hot water treatment for 30 seconds (L) (all still 100% gerrmination) (Table 3). However the rate of germination is affected by these treatments. Despite % germination being improved by seed storage, there are no differences in germination rate between fresh and older seeds (up to 1 year) (Table 4). Imbibition and germination for seeds in sand under a long photoperiod (E) is extremely rapid and uniform: ~2 days to start, with 50% of germinants achieved by 7 days after planting.

3.3.44 *Ziziphus zeyheriana* (shrublet)

Around 66% of seeds were intact. Post-harvest, up to 29% had latent defects and up to 71% of intact seeds were viable (Table 1). This species has no light requirement for germination, and 100% germination was achieved simply by exposure to moisture in the dark (A) (Table 3). Germination was very extended (Table 4): 3 days to start, with 50% of germinants by 26 days after treatment.

4. Discussion

All 46 species examined except for *A. elata*, *G. krebsiana* and *N. hottentottica* produced viable seed. In general, the herbaceous resprouters produced comparatively less viable seed than trees, shrubs and forbs. Many seeds classed as non-viable or of low viability had been obviously predated or contained insect larvae. Whereas *Acacia* seeds would contain the larvae of bruchid beetles (Szentesi & Jermy, 1995), cucurbit fruit contained iridescent purple and green weevils, and *Sutherlandia* pods contained small flies. Seeds that had been predated or contained larvae were invariably also infected by fungi during germination, whereas few non-predated viable seeds and late-aborted or senescent seeds were infected. Two germination treatments killed endogenous insect larvae, and prevented or delayed seed-coat infection by fungi and bacteria in a dose-dependent fashion (smoke and transient incubation in hot water at 94°C). Hot water treatment is known to inhibit seed decay due to sterilization (D. Mycock, pers comm.). Smoke could potentially also have sterilized seed coats. Smoke from burning savanna vegetation is known to contain the gas methyl bromide, a powerful fumigant used commercially to sterilize soil. When precipitated, the smoke used in our experiment contained substantial bromine (I.M. Weiersbye & W.J. Przybylowicz, unpublished data) suggesting that methyl bromide gas may have contributed to seed sterilization and the demise of endogenous seed bruchid, weevil, wasp and fly larvae found during this study. Adult insects that were about to emerge were not killed by smoke treatment. The sterilization effects afforded by smoke may therefore contribute to seed shelf-life and germination success simply by inhibiting decay and predation.

Some species were tested when their seeds were freshly harvested and at intervals up to a year later in order to establish seed dormancy pattern and requirements for post-maturation drying, as well as seed shelf-life and changes in germination responses with age. The effects of seed age on seed fate and germination were largely species-specific, and influenced by seed batch and age. This is in agreement with previous research on the same and related species in grasslands and savannas (Andersson & Milberg, 1998; Baskin & Baskin, 1998 and references therein; Milberg & Andersson, 1998; Witkowski & Mbalo, 2002). Seeds from the majority of the species tested exhibited survival up to 1 year (the duration of this study) if they were stored dry, but most died rapidly if stored in damp conditions.

Within species, patterns of seed viability and imbibition rates were directly related to differences in mass as found by Milberg *et al.* (1996). The viability status of untreated seeds could also be directly related to the relative proportion of water they imbibed over 48 hours. The dry mass of seeds of all species increased from non-viable to high viability seeds, whereas untreated seeds of most species took up water in the trend of high viability<low viability<non-viable. This is interpreted as either, (a) indicating that the seed coat and membrane of non-viable seeds cannot regulate water uptake (especially in species with relatively impermeable seed coats), and thus allows water to enter the seed in an 'uncontrolled' manner, or (b) due to greater permeability to water by the lower density tissues of less viable seeds (these seeds were often of the same volume as viable seeds but of lower mass). These data corroborate the vital stain viability data by indicating the viability-status of seeds using seed mass and seed moisture uptake as physical measures. The species that showed exception to this trend were *Mundulea sericea* (with impermeable seed coats) and *Asclepias fruticosa* (seeds of which did not prevent moisture uptake, and may therefore have no requirement or tolerance for post-maturation drying).

The majority of species could be germinated with relatively simple cues. Germination of all hard seed-coated legumes was achieved by mechanical disruption of the seed coat (i.e. scarification or high temperature treatments). Small, hard-coated, legume seeds generally required longer incubation at high temperature than larger, hard-coated, legume seeds. The largest Acacia seeds (of *A. hereroensis*) did not require scarification or heat treatment in order to germinate, although the large seeds of *E. elephantina* did. Seeds of *Berkheya setifera*, *Euclea crispa*, *Nolletia rarifolia*, *Salvia verbenacea* and *Senecio scitus* failed to germinate with the treatments attempted.

Some treatments influenced the timing and rate of germination (without necessarily resulting in changes in the overall percentage germination). Some simple treatments (i.e. light, heat, scarification, smoke) could decrease or increase germination rates, as well as breaking dormancy. Smoke exposure speeded up germination rate in *A. fruticosa*, whereas light decreased germination rate in *I. adenoides*, and increased germination rate in a number of other species.

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Table 1. Numbers of fruits and seeds assessed and seed fate (mean ± standard error) for each species assessed

Species	No. of (individuals)	No. of fruit sampled	No. of seeds sampled	Seeds/ fruit	Intact seeds/ fruit	% Intact of total	% Aborted of total	% Predated of total	% Viability of total	% High viability of intact	% Non+low viable of intact
Acacia erioloba	9	130	796	4.71±0.22	1.30±0.17	30.1±4.3	22.2±3.6	47.6±7.2	9.2±1.8	22.0±3.0	88.0±3.0
Acacia hebeclada	10	160	1013	6.45±0.40	1.97±0.39	29.2±4.5	37.5±5.2	33.2±2.2	20.4±5.2	58.0±18.0	42.0±18.0
Acacia hereroense	10	200	1182	5.91±0.14	1.49±0.22	25.0±3.4	46.1±1.9	28.9±3.6	20.0±2.0	70.0±2.0	30.0±2.0
Acacia karroo	15	270	2312	8.67±0.24	7.27±0.24	83.9±1.7	9.3±1.1	6.8±1.5	74.9±4.0	76.0±8.3	24.0±8.3
Acacia robusta spp.*robusta*	6	-	300	-	-	85.0±1.5	-	15.0±1.5	29.7±3.9	34.7±4.3	65.3±4.3
Acanthosiscyos naudiniana	11	15	1902	136±25	124±23	90.8±3.2	3.7±1.2	5.5±2.4	67.2±8.4	58.0±17.9	42.0±17.9
Asclepias fruticosa	14	14	1442	103±6	43.8±12.9	46.3±13.0	0.0±0.0	53.7±13.0	28.4±8.1	52.0±23.4	48.0±23.4
Asparagus laricinus	5	100	121	1.21±0.06	0.97±0.07	79.9±2.9	0.0±0.0	20.1±2.9	79.9±4.1	100.0±0.0	0.0±0.0
Aster harveyanus	10	25	4022	-	-	92.0±7.8	8.0±7.8	-	83.0±7.1	90.2±8.5	9.8±8.5
Athrixia elata	10	25	-	-	-	0.0±0.0	0.0±0.0	-	0.0±0.0	-	-
Berkheya setifera	5	20	-	-	-	100.0±0.0	0.0±0.0	-	15.0±0.0	5.0±0.0	75.0±0.0
Carpobrotus edulis	5	5	100	-	-	100.0±0.0	0.0±0.0	0.0±0.0	-	54.4±14.1	45.6±14.1
Clematis brachiata	10	200	200	1.0±0.0	1.0±0.0	100.0±0.0	0.0±0.0	0.0±0.0	60.0±0.0	60.0±0.0	40.0±0.0
Clutia monticola	4	44	-	-	-	100.0±0.0	0.0±0.0	0.0±0.0	100.0±0.0	100.0±0.0	0.0±0.0
Coccinia sessilifolia	5	5	437	87.4±7.8	85.4±8.2	97.6±1.7	0.0±0.0	2.4±1.7	69.2±6.5	48.9±11.2	51.1±11.2
Cucumis myriocarpus	8	20	1091	62.5±8.9	52.1±9.2	87.8±8.0	0.0±0.0	12.2±8.0	86.0±1.8	98.0±2.0	2.0±2.0
Delosperma herbeum	5	100	2012	-	-	100.0±0.0	0.0±0.0	0.0±0.0	52.3±6.4	52.3±6.4	47.7±6.4
Dicerocaryum eriocapum	5	20	105	5.25±0.26	3.80±0.69	71.3±11.1	10.5±5.5	18.2±8.6	-	-	-
Diospyros lycioides	15	220	481	2.23±0.15	76.8±6.5	76.8±6.5	1.42±0.70	60.7±8.4	60.7±8.4	59.0±19.7	41.0±19.7
Diospyros whyteana	2	50	-	-	80.3±7.2	80.0±7.2	-	-	80.3±17.2	100.0±0.0	0.0±0.0
Elephantorrhiza elehantina	20	200	-	-	97.5±12.3	97.5±12.3	0.0±0.0	2.5±12.3	97.5±12.3	100.0±0.0	0.0±0.0
Euclea crispa var. *crispa*	5	100	99	0.99±0.01	0.86±0.06	86.9±6.0	0.0±0.0	13.1±6.0	31.3±3.0	36.0±4.32	64.0±4.3
Gazania krebsiana var. *serrulata*	5	20	72	-	0.0±0.0	0.0±0.0	100.0±0.0	-	0.0±0.0	-	-
Grewia flava	5	35	123	3.51±0.15	2.17±0.27	61.1±5.0	22.1±3.1	16.8±5.1	29.3±2.3	48.0±1.1	52.0±1.1
Gymnosporia polyacantha	30	600	1070	1.78±0.06	1.49±0.06	83.3±1.7	9.0±1.3	7.6±1.2	47.7±12.3	36.0±15.1	64.0±15.1
Helichrysum nudifolijm	5	100	-	-	-	38.2±5.3	-	-	-	60.7±11.3	39.3±11.3
Helichrysum rugulosum	5	200	-	-	-	65.0±7.0	35.0±7.0	-	31.5±19.5	45.8±25.1	54.2±25.1
Indigofera adenoides	5	100	635	6.35±0.57	5.68±0.55	89.5±3.1	1.4±0.6	9.1±3.0	71.0±0.0	85.5±3.0	14.5±3.0
Leonotis leonuris	3	25	457	-	-	100.0±0.0	0.0±0.0	0.0±0.0	91.3±12.2	91.3±12.2	8.8±12.2
Lippia scaberimma	15	90	5742	64.6±2.5	35.7±7.3	57.4±11.4	8.9±4.0	33.7±12.5	12.7±10.3	23.3±18.6	76.7±18.6
Lopholaena corifolia	20	200	1712	-	-	73.0±14.2	27.0±14.2	-	73.0±14.2	100.0±0.0	0.0±0.0
Monsonia burkeana	5	25	40	-	-	100.0±0.0	0.00±0.0	-	8.0±0.0	8.0±0.0	92.0±0.0
Mundulea sericea	7	70	491	7.01±0.01	2.46±0.29	35.1±4.2	41.3±4.0	23.6±2.0	5.0±0.7	14.3±1.9	85.7±1.9

Species (individuals)	No. of	No. of fruit sampled	No. of seeds sampled	Seeds/ fruit	Intact seeds/ fruit	% Intact of total	% Aborted of total	% Predated of total	% Viability of total	% High viability of intact	% Non+low viable of intact
Nidorella hottentotica	5	100	-	-	-	100.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	100.0±0.0
Nolletia rarifolia	5	100	-	-	-	100.0±0.0	0.0	-	12.0±0.7	12.0±0.7	88.0±0.7
Pollichia campestris	10	100	-	-	-	86.5±13.5	-	13.5±13.5	49.5±12.5	61.0±24.0	39.0±24.0
Rhus iancea	10	120	172	2.22±0.43	0.51±0.17	92.7±2.9	0.0±0.0	7.3±2.9	70.5±11.4	64.0±7.2	36.0±7.2
Rhus pyroides	10	200	202	1.01±0.01	0.95±0.03	93.7±2.9	0.0±0.0	6.3±2.9	25.9±8.4	35.2±11.6	64.8±11.6
Salvia verbenacea	5	25	202	-	-	100.0±0.0	0.0±0.0	0.0±0.0	80.1±11.3	72.1±11.3	27.0±11.3
Senecio scitus	11	50	1107	-	-	44.0±0.0	56.0±0.0	-	22.0±0.0	50.0±0.0	50.0±0.0
Solanum incanum	4	5	500	-	-	100.0±0.0	0.0±0.0	0.0±0.0	81.5±18.5	81.5±18.5	18.5±18.5
Stoebe vulgaris	3	150	-	-	-	61.7±26.0	-	39.3±26.0	11.0±6.1	9.9±9.6	90.4±9.6
Sutherlandia frutescens	12	503	-	7.2±1.1	-	94.2±6.8	0.0±0.0	15.8±6.8	94.2±6.8	100.0±0.0	0.0±0.0
Triumfetta sonderi	5	35	51	1.46±0.10	0.43±0.16	28.7±9.1	19.2±3.6	52.1±11.0	12.3±1.7	14.3±2.4	85.7±2.4
Ziziphus mucronata	10	200	236	1.18±0.04	0.90±0.08	75.4±5.8	18.8±5.3	5.8±2.3	54.3±3.0	62.0±6.0	38.0±6.0
Ziziphus zeyheriana	5	25	52	2.08±0.05	1.36±0.15	65.6±7.5	26.4±8.8	8.0±3.7	57.7±6.3	80.0±1.2	20.0±1.2

Table 2. Seed air-dry mass and percentage imbibition. Sample size was 25 seeds/ individual from 5 individuals and data are means ± standard errors. Seeds were subsequently tested for viability

Species	Viability category	Seed dry mass (mg)	Percentage water uptake after 48 hours (% of dry mass)
Acacia hebeclada	Non-viable	124±32	26.5±6.5
	Low viability	152±25	23.5±3.5
	High viability	182±41	00±0.0
Acacia hereroensis	Non-viable	65±6	144±15
	Low viability	89±14	35±0.0
	High viability	94±7	17±4.0
Acacia karroo	Non-viable	39±5	171±40
	Low viability	48±10	28±24
	High viability	50±14	10±10
Acanthosiscyos naudiniana	Non-viable	42.2±3.4	228±43
	Low viability	102±54	123±43
	High viability	114±49	106±41
Asclopias fruticosa	Non-viable	2.6±0.5	315±27
	Viable	2.9±0.1	379±19
Asparagus laricinus	Non-viable	19.4±5.9	34±0.8
	Low viability	21.3±3.7	30±1.2
	High viability	28.5±0.9	29±1.1
Coccinia sessilifolia	Non-viable	20.3±2.9	145±16
	Low viability	76.3±4.7	41±13
	High viability	77.3±5.1	29±3
Cucumis myriocarpus	Non-viable	2.7±0.6	200±34
	Viable	6.6±0.6	39±20
Diospyros lycioldes	Non-viable	130±19	21±4
	Low viability	122±25	18±6
	High viability	154±11	14±4
Euclea crispa	Non-viable	6.4±0.5	-
	Viable	7.1±0.8	-
Gymnosporia polyacantha	Non-viable	4.4±0.5	115±11
	Low viability	4.7±0.6	113±15
	High viability	5.9±0.3	96±14
Mundulea sericea	Non-viable	13.7±06	0.0±0.0
	Low viability	15.4±1.2	0.0±0.0
	High viability	22.4±3.0	0.0±0.0
Rhus lancea	Non-viable	23.0±1.0	38±2.4
	Low viability	22.0±2.0	39±3.2
	High viability	24.4±1.0	36±2.0
Rhus pyroldes	Non-viable	8.8±1.3	94.3±2.3
	Low viability	9.6±0.8	81.5±1.5
	High viability	13.5±0.4	58.0±9.8
Triumfetta sonderi	Non-viable	3.5±03	389±3.3
	Low viability	7.6±1.1	253±21
	High viability	11.02±2.1	117±24
Ziziphus mucronata	Non-viable	12.2±1.1	132±17
	Low viability	21.8±2.6	76.0±0
	High viability	22.9±3.3	58±15
Ziziphus zeyheriana	Non-viable	50.6±1.4	24±2.0
	Low viability	57.1±0.3	35±1.1
	High viability	54.6±1.2	19±1.3

Table 3. Summary of treatment effects on germination. Data are means ± standard errors. For treatment codes see Appendix 1

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
Acacia erioloba:								
< 6	A	30.1±4.3	0.0±0.0	36.9	0.0	0.0±0.0	100.0±0.0	0.0±0.0
< 6	B	30.1±4.3	11.1±1.0	36.9	36.9	0.0±0.0	0.0±0.0	100.0±0.0
< 6	D	30.1±4.3	0.0±0.0	-	-	0.0±0.0	100.0±0.0	0.0±0.0
< 6	L	30.1±4.3	9.2±0.0	-	-	0.0±0.0	0.0±0.0	100.0±0.0
< 6	M	30.1±4.3	10.6±0.04	-	-	0.0±0.0	0.0±0.0	100.0±0.0
< 6	N	30.1±4.3	9.8±0.8	-	-	20.7±14.2	0.0±0.0	79.3±14.2
< 6	P	30.1±4.3	0.0±0.0	-	-	100.0±0.0	0.0±0.0	0.0±0.0
Acacia hebeclada:								
< 6	A	29.2±8.9	8.4±4.3	41.3±21.3	26.7±6.7	0.0	23.3±23.3	76.7±23.3
< 6	B	38.1	38.1	100.0	100.0	0.0	0.0	100.0
< 6	C	29.2±5.0	0.76±0.76	70.0±18.0	2.0±2.0	0.0	0.0	2.3±2.3
>6	E	20.4	0.0	37.5	0.0	0.0	100.0	0.0
>6	F	20.4	0.0	40.0	0.0	0.0	100.0	0.0
>6	G	20.4	1.7	37.5	8.3	0.0	77.8	22.2
>6	H	20.4	0.0	44.0	0.0	18.2	81.8	0.0
>6	I	53.9	10.8	20.0	20.0	0.0	0.0	100.0
>6	L	53.9	6.5	52.0	12.0	0.0	76.9	23.1
>6	N	53.9	0.0	32.0	0.0	12.5	87.5	0.0
>6	P	53.9	2.2	76.0	4.0	89.5	5.3	5.3
>6	Q	53.9	4.3	72.0	8.0	0.0	88.9	11.1
Acacia hereroensis:								
< 6	A	24.0±7.8	8.0±1.5	33.3±4.2	33.3±4.2	0.0	0.0	100.0
< 6	C	25.0±7.8	2.3±0.3	80.0±8.0	10.0±2.0	0.0	0.0	12.4±1.3
>6	E	25.0±7.8	5.8±0.7	27.6±7.6	24.7±4.7	0.0	0.0	91.7±8.3
>6	F	25.0±7.8	5.9±0.7	30.0±5.0	25.0+5.0	0.0	7.1±7.1	82.9±2.9
>6	G	25.0±7.8	9.4±2.9	37.5±0.0	37.5±0.0	0.0	0.0	100.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
>6	H	25.0±7.8	6.0±1.3	42.9±20.7	24.7±2.5	7.1±7.1	14.3±14.3	71.4±28.6
Not shed	A	82.5±1.4	13.6±10.0	75.0±16.7	16.7±12.5	0.0	72.7±22.7	27.3±22.7
Not shed	D	85.4±1.5	49.3±14.4	89.7±3.6	57.5±15.8	0.0	36.5±15.1	63.5±15.1
<6	B	81.1	81.1	100.0	100.0	0.0	0.0	100.0
<6	C	83.9±1.7	22.7±21.1	89.3±4.8	28.0±26.0	0.0	0.0	30.7±28.2
>6	E	84.0±2.9	6.9±3.3	79.2±8.3	8.3±4.2	0.0	88.8±6.4	11.2±6.4
>6	F	84.0±2.9	1.7±1.7	90.0±2.5	2.1±2.1	0.0	97.6±2.4	2.4±2.4
>6	G	84.0±2.9	6.9±3.3	91.7±4.2	8.3±4.2	0.0	90.7±5.0	9.3±5.0
>6	H	84.0±2.9	5.3±1.9	89.6±2.1	6.3±2.1	7.1±7.1	85.9±5.0	6.9±2.2
>6	I	84.0±2.9	79.1±7.8	94.0	94.0±6.0	0.0	0.0	100.0
>6	J11	81.1	56.7	100.0	70.0	0.0	0.0	70.0
>6	J12	81.1	44.6	95.0	55.0	0.0	0.0	57.9
>6	L	84.0±2.9	41.9±0.2	100.0	50.0±2.0	0.0	50.0±2.0	50.0±2.0
>6	N	84.0±2.9	70.1±11.0	98.0±2.0	84.0±16.0	14.6±14.6	0.0	85.4±14.6
>6	P	84.0±2.9	0.0	90.0±2.0	0.0	97.8±2.2	2.2±2.2	0.0
>6	Q	84.0±2.9	5.0±1.5	76.0±4.0	6.0±2.0	0.0	91.9±3.1	8.1±3.1
Acacia robusta spp. *robusta:*								
<6	D	85.0	17.9	100.0	21.0	0.0	79.9	21.0
<6	E	85.0	10.2	100.0	12.0	0.0	88.0	12.0
<6	M	85.0	27.2	100.0	32.0	0.0	68.0	32.0
<6	N	85.0	51.9	100.0	61.0	0.0	39.0	61.0
<6	O	85.0	85.0	100.0	100.0	0.0	0.0	100.0
Acanthosiscyos naudiniana:								
<6	A	92.7	0.0	70.8	0.0	0.0	0.0	0.0
<6	B	92.7	0.0	100.0	0.0	100.0	0.0	0.0
<6	C	91.7±0.9	0.0	62.0±14.0	0.0	0.0	0.0	0.0
Aslepias fruticosa:								

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
<6	A	49.9±25.2	27.3±27.3	38.7±22.3	27.8±27.8	0.0	0.0	33.3±33.3
<6	C	49.9±25.2	0.0	61.3±17.5	0.0	0.0	0.0	0.0
<6	D	24.8±4.8	1.2±1.2	16.3±0.3	6.0±6.0	0.0	0.0	37.5±37.5
<6	R	24.8±4.8	0.0	16.7±0.0	0.0	50.0±50.0	0.0	0.0
>6	E	20.0	7.5	37.5	37.5	0.0	0.0	100
>6	F	20.0	16.5	82.5	82.5	0.0	0.0	100
>6	G	20.0	0.0	87.5	0.0	47.6	0.0	0.0
>6	H	20.0	0.0	83.3	0.0	60.0	0.0	0.0
Asparagus laricinus:								
<6	A	79.9	63.2	95.8	79.2	0.0	0.0	82.9
<6	C	79.9	79.9	100.0	100.0	0.0	0.0	100.0
<6	E	79.9	73.2	91.7	91.7	0.0	0.0	100.0
>6	F	79.9	63.9	80.0	80.0	0.0	0.0	100.0
>6	G	79.9	69.9	95.8	87.5	0.0	0.0	91.3
>6	H	79.9	49.9	95.8	62.5	0.0	0.0	65.2
>6	I	79.9	57.5	72.0	72.0	0.0	0.0	100.0
>6	L	79.9	25.6	88.0	32.0	0.0	0.0	36.4
>6	N	79.9	12.8	96.0	16.0	8.3	0.0	16.7
>6	P	79.9	6.4	92.0	8.0	8.7	0.0	8.7
>6	Q	79.9	44.7	84.0	56.0	4.8	0.0	66.7
>6	R	79.9	79.9	100.0	100.0	0.0	0.0	100.0
Aster harveyanus:								
>6	A	92.0	0.0	70.0	0.0	0.0	0.0	0.0
>6	D	92.0	44.2	70.0	48.0	0.0	0.0	68.6
Carpobrotus edulis:								
>6	E	100.0	50.0	54.0	50.0	0.0	0.0	92.6
Clematis brachiata:								

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
<6	A	100.0	0.0	58.3	0.0	0.0	14.3	0.0
<6	C	100.0	0.0	60.0	0.0	0.0	0.0	0.0
<6	D	100.0	75.0	100.0	75.0	0.0	0.0	75.0
<6	R	100.0	0.0	60.0	0.0	0.0	0.0	0.0
Clutia monticola:								
<6	C1	100.0	23.1	76.9	23.1	0.0	0.0	30.0
<6	D	100.0	0.0	76.9	0.0	0.0	0.0	0.0
Coccinia sessilifolia:								
<6	A	97.6	0.0	40.0	0.0	0.0	-	0.0
<6	B	97.6	0.0	40.0	0.0	0.0	-	0.0
<6	C	97.6	0.0	84.0	0.0	0.0	-	0.0
Cucumis myriocarpus:								
<6	A	80.5	6.4	64.0	8.0	0.0	87.5	12.5
<6	C	80.5	0.0	96.0	0.0	0.0	0.0	0.0
<6	D	80.5	0.0	60.9	0.0	0.0	0.0	0.0
<6	R	80.5	0.0	66.7	0.0	0.0	0.0	0.0
Delosperma herbeum:								
>6	A	100.0	37.0	52.0	37.0	0.0	0.0	37.0
>6	D	100.0	52.0	52.0	52.0	0.0	0.0	100.0
Diospyros lycioides ssp. *lycioides:*								
<6	A	87.9±1.7	8.4±5.1	75.0±14.6	9.7±6.1	0.0	0.0	11.0±6.9
<6	B	87.9±1.7	51.1±26.8	98.2±1.8	57.9±29.9	0.0	0.0	59.3±30.3
<6	C	85.1±3.0	18.2±18.2	79.0±10.9	20.0±20.0	0.0	0.0	21.7±21.7
>6	E	90.8	79.5	100.0	87.5	0.0	0.0	87.5
>6	F	90.8	76.8	92.3	84.6	0.0	0.0	91.7
>6	G	90.8	73.4	100.0	80.8	0.0	0.0	80.8
>6	H	90.8	56.8	91.7	62.5	0.0	0.0	68.2
>6	I	90.8	87.2	96.0	96.0	0.0	0.0	100.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
>6	L	90.8	87.2	100.0	96.0	4.0	0.0	96.0
>6	N	90.8	0.0	96.0	0.0	29.2	0.0	0.0
>6	P	90.8	0.0	96.0	0.0	41.7	0.0	0.0
>6	Q	90.8	0.0	96.0	0.0	0.0	0.0	0.0
<6	R	84.8	0.0	80.0	0.0	0.0	0.0	0.0
Diospyros whyteana:								
>6	A	80.3±7.2	0.0	85.0	0.0	0.0	71.7	28.3
>6	E	80.3±7.2	68.3	85.0	85.0	0.0	0.0	100.0
Elephantorrhiza elephantina:								
>6	B	97.5	97.5	100.0	100.0	0.0	0.0	100.0
>6	E	97.5	22.3	100.0	21.7	0.0	78.3	21.7
>6	L	97.5	97.5	100.0	100.0	0.0	0.0	100.0
Euclea crispa:								
<6	A	87.0	0.0	24.0	0.0	0.0	0.0	0.0
<6	C	87.0	0.0	36.0	0.0	0.0	0.0	0.0
<6	D	87.0	0.0	100.0	0.0	0.0	0.0	0.0
Grewia flava:								
<6	A	61.1	4.9	40.0	8.0	0.0	80.0	0.0
<6	C	61.1	29.3	48.0	48.0	0.0	0.0	100.0
<6	D	61.1	0.0	100.0	0.0	0.0	0.0	0.0
<6	R	61.1	0.0	63.6	0.0	0.0	0.0	0.0
Gymnosporia polyacantha:								
<6	A	84.8±3.7	0.0	26.7±5.9	0.0	0.0	0.0	0.0
<6	C	84.5±2.9	0.0	68.0±12.6	0.0	0.0	0.0	0.0
<6	D	84.8±3.7	0.0	26.7±5.9	0.0	0.0	0.0	0.0
>6	E	87.5±3.6	7.6±4.0	66.7±8.7	8.3±4.2	0.0	0.0	11.5±4.3
>6	F	87.5±3.6	7.8±7.8	80.3±9.7	8.3±8.3	49.6±10.0	0.0	8.7±8.7
>6	G	87.5±3.6	2.4±1.2	81.9±9.7	2.8±1.4	83.5±5.3	0.0	3.7±2.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
>6	H	87.5±6.2	0.0	76.4±12.7	0.0	79.3±27.1	0.0	0.0
>6	L	93.7	0.0	100.0	0.0	12.0	0.0	0.0
>6	N	93.7	0.0	96.0	0.0	100.0	0.0	0.0
>6	P	93.7	0.0	84.0	0.0	100.0	0.0	0.0
>6	Q	93.7	0.0	76.0	0.0	26.3	0.0	0.0
<6	R	84.8±3.7	0.0	26.8±6.4	0.0	0.0	0.0	0.0
Helichrysum nudifolium:								
>6	D	38.2	2.9	23.3	7.7	-	-	33.0
Helichrysum rugulosum:								
<6	A	58.0	0.3	21.0	0.0	0.0	0.0	0.0
<6	D	58.0	2.3	21.0	4.0	0.0	0.0	19.0
Indigofera adenoides:								
<6	A	89.5	28.7	52.0	32.0	0.0	38.5	61.5
<6	C	89.5	29.8	33.3	33.3	0.0	0.0	100.0
<6	C1	85.5	3.4	16.0	4.0	0.0	0.0	25.0
<6	D	89.5	19.9	33.3	22.2	0.0	0.0	66.7
<6	R	89.5	0.0	33.3	0.0	0.0	0.0	0.0
Leonotis leonurus:								
<6	D	100.0	91.3	91.3	91.3	0.0	0.0	100.0
Lippia scaberimma:								
<6	A	86.1±10.2	6.1±6.1	49.5±25.5	8.0±8.0	0.0	66.7±33.3	33.3±33.3
<6	C	75.9	0.0	10.0	0.0	0.0	100.0	0.0
<6	C1	49.8	4.0	40.0	8.0	0.0	0.0	20.0
<6	D	86.1±10.2	30.7±30.7	45.7±36.1	31.8±31.8	0.0	0.0	38.9±38.9
<6	R	75.9	0.0	10.0	0.0	100.0	0.0	0.0
Lophalaena corrifolia:								
<6	A	73.0	0.0	100.0	0.0	0.0	0.0	0.0
<6	D	73.0	73.0	100.0	100.0	0.0	0.0	100.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
Monsonia burkeana:								
<6	C1	100.0	8.0	8.0	8.0	0.0	0.0	100.0
<6	D	100.0	0.0	8.0	0.0	0.0	0.0	0.0
Mundulea sericea:								
<6	A	79.3	6.0	25.0	0.0	0.0	0.0	0.0
<6	C	79.3	3.2	24.0	4.0	0.0	0.0	16.7
>6	D	35.1	9.1	100.0	26.0	0.0	74.0	26.0
>6	E	35.1	7.0	100.0	26.0	0.0	0.0	20.0
>6	M	35.1	17.6	100.0	50.0	0.0	50.0	50.0
>6	N	35.1	33.0	100.0	94.0	0.0	6.0	94.0
>6	O	35.1	35.1	100.0	100.0	0.0	0.0	100.0
Nolletia rarifolia:								
<6	D	100.0	0.0	12.0	0.0	0.0	0.0	0.0
Pollichia campestris:								
<6	A	91.0	0.0	16.7	0.0	0.0	50.0	0.0
<6	C1	100.0	20.0	76.0	20.0	0.0	0.0	26.3
>6	D	100.0	9.0	31.0	9.0	0.0	71.0	29.0
<6	R	91.0	8.3	9.1	9.1	0.0	0.0	100.0
Rhus lancea:								
<6	A	97.4	0.0	40.0	0.0	0.0	0.0	0.0
<6	C	97.4	0.0	76.0	0.0	0.0	0.0	0.0
<6	D	97.4	19.5	40.0	20.0	0.0	0.0	50.0
>6	E	97.4	56.8	79.2	58.3	0.0	0.0	73.7
>6	F	97.4	65.7	82.5	67.5	9.1	0.0	81.8
>6	G	97.4	84.1	95.5	86.4	4.8	0.0	90.5
>6	H	97.4	52.8	79.2	54.2	15.8	0.0	68.4
>6	I	97.4	54.5	92.0	56.0	13.0	0.0	60.9
>6	L	97.4	11.7	100.0	12.0	80.0	0.0	12.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
>6	N	97.4	11.7	92.0	12.0	87.0	0.0	13.0
>6	P	97.4	11.7	92.0	12.0	87.0	0.0	13.0
>6	Q	97.4	0.0	96.0	0.0	83.3	0.0	0.0
>6	R	97.4	0.0	63.6	0.0	0.0	0.0	0.0
Rhus pyroides:								
<6	A	93.7±5.3	0.0	43.0±7.0	0.0	0.0	0.0	0.0
<6	C	81.4±10.5	0.0	45.0±16.7	0.0	0.0	0.0	0.0
<6	D	93.7±5.3	0.0	68.0±32.0	0.0	0.0	0.0	0.0
<6	R	99.0	0.0	83.3	0.0	0.0	0.0	0.0
Salvia verbenacea:								
<6	C1	100.0	0.0	80.0	0.0	0.0	0.0	0.0
Senecio scitus:								
<6	D	44.0	0.0	50.0	0.0	0.0	100.0	0.0
Solanum incanum:								
<6	A	87.2±2.8	0.0	100.0	0.0	0.0	100.0	0.0
<6	C	87.2+2.8	45.0±45.0	81.5±18.5	50.0±50.0	0.0	50.0±50.0	50.0±50.0
<6	D	86.3+1.9	0.0	100.0	0.0	0.0	97.7±2.3	0.0
<6	R	87.2+2.8	87.2±2.8	100.0	100.0	0.0	0.0	100.0
Stoebe vulgaris:								
<6	D	60.0	55.0	45.0	30.6	0.0	0.0	68.0
Triumfetta sonderi:								
<6	A	28.7	0.0	41.7	0.0	0.0	0.0	0.0
<6	C	39.3	0.0	40.0	0.0	0.0	100.0	0.0
<6	D	39.3	3.1	40.0	8.0	0.0	80.0	20.0
<6	R	28.7	0.0	42.9	0.0	0.0	0.0	0.0
Ziziphus mucronata:								
<6	A	75.4±14.6	11.2±4.0	71.3±4.7	16.5±8.5	34.2±34.2	0.0	24.0±13.5
<6	B	60.8	6.1	100.0	10.0	90.0	0.0	10.0

Seed age (mths)	Treatment code	% of Total seeds		% of Intact seeds		% of Viable seeds		
		Intact	Germinated	Viable	Germinated	Killed	Unimbibed	Germinated
<6	C	75.4±14.6	0.0	72.0±4.0	0.0	0.0	0.0	0.0
>6	E	90.0	82.5	91.7	91.7	0.0	0.0	100.0
>6	F	90.0	63.0	70.0	70.0	0.0	0.0	100.0
>6	G	90.0	63.8	70.8	70.8	0.0	0.0	100.0
>6	H	90.0	78.8	87.5	87.5	0.0	0.0	100.0
>6	I	90.0	79.2	88.0	88.0	0.0	0.0	100.0
>6	K11	90.0	58.5	100.0	65.0	0.0	0.0	65.0
>6	K12	90.0	40.5	100.0	45.0	0.0	0.0	45.0
>6	L	90.0	90.0	100.0	100.0	0.0	0.0	100.0
>6	N	90.0	54.0	76.0	60.0	21.1	0.0	78.9
>6	P	90.0	36.0	100.0	40.0	60.0	0.0	40.0
>6	Q	90.0	82.8	92.0	92.0	0.0	0.0	100.0
Ziziphus zeyheriana:								
<6	A	65.6	46.3	70.6	70.6	0.0	0.0	100.0
<6	C	65.6	0.0	88.0	0.0	0.0	0.0	0.0

Table 4. Summary of treatment effects on the progress of seed imbibitions and germination. Data are means ± errors. For Key to treatment codes see Appendix II

OF VIABLE SEEDS IMBIBITION:						GERMINATION:				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
Acacia erioloba:										
<6	B	36.9	36.9	-	-	36.9	3.2±0.5	4.0	2.7±1.3	6.3±1.4
Acacia hebeclada:										
<6	A	41.3±21.3	76.7±23.3	11.9±0.7	6.5±1.5	76.7±23.3	17.4±0.6	16.3±0.8	9.0±6.0	17.0±2.0
<6	B	100.0	100.0	1.0±0.0	1.0	100.0	11.0±0.0	11.0	11.0	11.0
<6	C	70.0±18.0	100.0	-	1.0±0.0	2.3±2.3	-	1.0	-	-
>6	E	37.5	0.0	-	-	0.0	-	-	-	-
>6	F	40.0	0.0	-	-	0.0	-	-	-	-
>6	G	37.5	22.2	6.0±0.0	6.0	22.2	15.0±3.0	15.0	12.0	15.0
>6	H	44.0	0.0	-	-	0.0	-	-	-	-
>6	I	20.0	100.0	1.0±0.0	1.0	100.0	4.2±0.8	5.0	1.0	5.0
>6	L	52.0	23.1	24.7±3.2	24.0	23.1	26.0±2.1	26.0	19.0	25.0
>6	N	32.0	12.5	-	15.0	0.0	-	-	-	-
>6	P	76.0	100.0	9.4±3.4	15.0	5.3	-	25.0	25.0	25.0
>6	Q	72.0	11.1	8.0±5.7	8.0	11.1	10.0±0.0	10.0	10.0	10.0
Acacia hereroensis:										
<6	A	33.3±4.2	100.0	3.2±0.7	3.0±0.0	100.0	4.3±0.4	4.0±0.0	3.5±0.5	4.0±0.0
<6	C	80.0±8.0	100.0	-	1.0±0.0	12.4±1.3	-	2.0±1.0	-	-
>6	E	27.7±7.6	91.7±8.3	12.3±2.7	12.0±3.0	91.7±8.3	13.8±1.2	13.5±1.5	10.5±1.5	13.5±1.5
>6	F	30.0±5.0	82.9±2.9	11.8±2.9	9.0±0.0	82.9±2.9	13.1±0.4	12.3±0.3	9.0±3.0	12.0±0.0
>6	G	37.5±0.0	100.0	12.8±2.3	10.5±1.5	100.0	14.6±1.4	15.0±0.3	6.0±0.0	12.0±0.0
>6	H	42.9±20.7	71.4±28.6	11.0±1.0	10.5±1.5	71.4±28.6	14.3±0.8	12.8±0.8	10.5±1.5	2.0±0.0
Acacia karroo:										
Not Shed	A	75.0±16.7	27.3±22.7	7.7±0.3	6.5±1.5	27.3±22.7	19.6±4.1	13.5±1.5	10.0±2.0	17.0±5.0
Not Shed	D	89.7±3.6	63.5±15.1	2.1±0.5	1.0	63.5±15.1	3.5±0.3	3.1	2.0	4.0
<6	B	100.0	100.0	2.1±0.0	1.0	100.0	8.0±1.4	7.5	4.0	4.0
<6	C	89.3±4.8	100.0	-	1.0±0.0	30.7±28.2	-	1.5±0.4	1.0	1.0

OF VIABLE SEEDS										
IMBIBITION:						**GERMINATION:**				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
>6	E	79.2±8.3	11.2±6.4	20.3±9.0	16.2±4.2	11.2±6.4	23.0±10.1	14.2±2.2	9.0±3.0	17.0±5.0
>6	F	90.0±2.5	2.4±2.4	-	25.0	2.4±2.4	-	31.0	31.0	31.0
>6	G	91.7±4.2	9.3±5.0	20.3±9.0	16.2±4.2	9.3±5.0	21.7±10.3	16.3±4.8	9.3±5.0	17.0±5.0
>6	H	89.6±2.1	6.9±2.2	26.5±14.5	31.8±5.3	6.9±2.2	26.5±14.5	33.8±7.3	26.5±14.5	26.5±14.5
>6	I	94.0±0.6	100.0	2.5±0.4	2.0±0.0	100.0	5.9±1.2	6.3±0.8	3.0±1.0	5.5±1.5
>6	J11	100.0	100.0	2.0±2.0	2.0	70.0	4.3±0.7	3.0	3.0	3.0
>6	J12	95.0	100.0	1.0±0.0	1.0	57.9	2.1±0.3	1.0	1.0	1.0
<6	L	100.0	50.0±2.0	5.0±3.0	4.5±2.5	50.0±2.0	7.2±0.8	7.0±0.0	3.0±1.0	7.0±0.0
<6	N	98.0±2.0	85.4±14.6	2.8±0.8	3.0±1.0	85.4±14.6	7.3±0.7	7.0±0.0	4.0±0.0	7.0±0.0
<6	P	90.0±2.0	100.0	2.8±0.8	3.0±1.0	0.0	-	-	-	-
<6	Q	76.0±4.0	10.6±0.6	4.6±2.6	3.0±1.0	8.1±3.1	9.0±5.0	9.5±5.0	7.0±3.0	7.0±3.0
Acacia robusta:										
<6	D	100.0	21.0	-	-	21.0	-	3.5	-	-
<6	E	100.0	12.0	-	-	12.0	41.3±5.5	20.0	18.0	20.0
<6	M	100.0	32.0	-	-	32.0	-	2.5	-	-
<6	N	100.0	61.0	-	-	61.0	-	2.5	-	-
<6	O	100.0	100.0	-	-	100.0	-	2.5	-	-
Asclepias fruticosa:										
<6	A	38.7±22.3	100.0	2.0±0.0	2.0	33.3±33.3	11.9±1.0	12.0	4.0	12.0
<6	C	61.3±17.5	100.0	-	1.0	0.0	-	-	-	-
<6	D	16.3±0.3	100.0	-	-	37.5±37.5	32.0±0.0	32.0	32.0	32.0
<6	R	16.7±0.0	100.0	-	1.0±0.0	0.0	-	-	-	-
>6	E	37.5	100.0	6.0±0.0	6.0	100.0	9.3±1.1	9.3	6.0	10.5
>6	F	82.5	100.0	3.0±0.0	3.0	100.0	9.7±0.4	12.0	3.0	6.0
>6	G	87.5	100.0	3.0±0.0	3.0	0.0	-	-	-	-
>6	H	83.3	100.0	3.0±0.0	3.0	0.0	-	-	-	-
Asparagus laricinus:										
<6	A	95.8	100.0	-	-	82.6	51.2±2.4	52.5	35.0	49.0
<6	C	100.0	100.0	-	1.0	100.0	-	3.0	-	-
>6	E	91.7	100.0	3.0±0.0	3.0	100.0	16.4±0.9	15.0	12.0	18.0

OF VIABLE SEEDS										
IMBIBITION:						**GERMINATION:**				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
>6	F	80.0	100.0	3.0±0.0	3.0	100.0	22.8±0.9	20.0	18.0	22.0
>6	G	95.8	92.6	3.0±0.0	3.0	91.3	33.5±1.9	37.0	18.0	37.0
>6	H	95.8	60.9	3.0±0.0	3.0	65.2	41.7±1.0	43.0	31.0	41.0
>6	I	72.0	100.0	5.0±0.0	5.0	100.0	14.1±0.7	15.0	8.0	15.0
>6	L	88.0	100.0	5.0±0.0	5.0	36.4	29.4±0.6	30.0	25.0	30.0
>6	N	96.0	100.0	1.0±0.0	1.0	16.7	28.8±1.3	30.0	25.0	30.0
>6	P	92.0	100.0	1.0±0.0	1.0	8.7	35.0±0.0	35.0	35.0	35.0
>6	Q	84.0	100.0	5.0±0.0	5.0	66.7	17.0±0.6	17.0	15.0	15.0
<6	R	100.0	100.0	-	1.0	100.0	-	2.0	-	-
<6	R	83.3±16.7	100.0	-	1.0±0.0	50.0±50.0	-	1.0	-	-
Aster harveyanus:										
<6	D	70.0	100.0	-	-	68.6	5.0±0.0	5.0	3.0	5.0
Carpobrotus edulis:										
>6	E	54.0	100.0	-	-	92.6	12.0±0.7	15.0	5.0	10.0
Clematis brachiata:										
<6	A	58.3	85.7	-	-	0.0	-	-	-	-
<6	C	60.0	100.0	-	-	0.0	-	-	-	-
<6	D	100.0	75.0	-	-	75.0	25.0±3.2	33.0	15.0	33.0
<6	D	30.0±0.0	100.0	-	-	0.0	-	-	-	-
<6	R	60.0	100.0	-	1.0	0.0	-	-	-	-
Clutia monticola:										
<6	C1	76.9	100.0	-	1.0	30.0	-	3.0	-	-
Cucumis myriocarpus:										
<6	A	64.0	12.5	-	-	12.5	6.5±2.5	6.5	4.0	9.0
<6	C	96.0	100.0	-	1.0	0.0	-	-	-	-
<6	D	60.9	100.0	-	-	0.0	-	-	-	-
<6	R	66.7	100.0	-	1.0	0.0	-	-	-	-
Delosperma herbeum:										
>6	D	52.0	100.0	-	-	100.0	10.7±0.1	10.0	10.0	10.0

OF VIABLE SEEDS										
IMBIBITION:						**GERMINATION:**				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
Dorotheanthus sp:										
>6	E	100.0	100.0	-	-	29.0	10.3±0.4	10.0	5.0	10.0
>6	K	100.0	100.0	-	-	0.0	-	-	-	-
Diospyros lyciodes:										
<6	A	75.0±14.6	69.7±30.3	5.8±1.1	7.5±1.8	11.0±6.9	30.1±6.6	31.0±7.3	27.5±4.5	29.0±5.7
<6	B	98.2±1.8	100.0	-	-	59.3±30.3	18.9±5.0	21.0±4.9	9.0±1.6	21.0±4.9
<6	C	79.0±10.9	100.0	-	1.0±0.0	21.7±21.7	-	2.0	-	-
>6	E	100.0	100.0	3.0±0.0	3.0	87.5	29.1±1.7	29.5	18.0	28.0
>6	F	92.3	91.7	6.6±0.3	6.0	91.7	35.5±1.6	40.5	22.0	37.0
>6	G	100.0	100.0	6.0±0.0	6.0	80.8	32.1±1.5	37.0	18.0	31.0
>6	H	91.7	100.0	6.0±0.0	6.0	68.2	36.3±1.7	37.0	22.0	37.0
>6	I	96.0	100.0	1.5±0.3	1.0	100.0	24.6±1.8	25.0	10.0	25.0
>6	L	100.0	100.0	1.0±0.0	1.0	96.0	33.8±1.4	35.0	19.0	35.0
>6	N	96.0	100.0	1.0±0.0	1.0	0.0	-	-	-	-
>6	P	96.0	100.0	1.0±0.0	1.0	0.0	-	-	-	-
>6	Q	96.0	100.0	1.0±0.0	1.0	0.0	-	-	-	-
<6	R	80.0	100.0	-	1.0	0.0	-	-	-	-
Diospyrus whyteana:										
>6	E	85.0	100.0	17.3±2.1	-	100.0	26.1±1.3	27.0	20.5	30.0
Elephantorrhiza elephantine:										
>6	B	100.0	100.0	-	-	100.0	5.5	6.0	3.0	5.0
>6	E	100.0	21.7	-	-	21.7	18.0	21.0	14.0	21.0
>6	L	100.0	100.0	-	-	100.0	5.5	6.0	3.0	5.0
Grewia flava:										
<6	A	40.0	20.0	-	-	20.0	7.0±0.0	7.0	7.0	7.0
<6	C	48.0	100.0	-	1.0	100.0	-	2.0	-	-
<6	D	100.0	100.0	-	-	0.0	-	-	-	-
<6	R	63.6	100.0	-	1.0	0.0	-	-	-	-
Gymnosporia polyacantha:										
<6	A	26.7±5.9	100.0±0.0	-	-	0.0	-	-	-	-

OF VIABLE SEEDS IMBIBITION:						GERMINATION:				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
<6	C	68.0±12.6	100.0	-	1.0±0.0	0.0	-	-	-	-
<6	D	26.7±5.9	100.0	-	-	0.0	-	-	-	-
>6	E	66.7±8.7	100.0	2.5±0.4	2.5±0.4	11.5±4.3	21.0±1.0	18.7±3.3	17.3±2.9	18.7±3.3
>6	F	80.3±9.7	100.0	2.5±0.4	2.5±0.4	8.7±8.7	21.2±2.2	25.0	12.0	22.0
>6	G	81.9±9.7	100.0	2.5±0.4	2.5±0.4	3.7±2.0	-	15.5±7.8	15.5±7.8	15.5±7.8
>6	H	76.4±12.7	100.0	2.5±0.7	2.5±0.7	0.0	-	-	-	-
>6	L	100.0	100.0	-	-	0.0	-	-	-	-
>6	N	96.0	100.0	-	-	0.0	-	-	-	-
>6	P	84.0	100.0	-	-	0.0	-	-	-	-
>6	Q	76.0	100.0	-	-	0.0	-	-	-	-
<6	R	26.8±6.4	100.0	-	1.0±0.0	0.0	-	-	-	-
Indigofera acutisepala:										
<6	A	52.0	61.5	-	-	61.5	13.9±5.9	4.0	2.0	4.0
<6	C	33.3	100.0	-	1.0	100.0	-	2.0	-	-
<6	C1	16.0	100.0	-	1.0	25.0	-	1.0	-	-
<6	D	33.3	100.0	-	-	66.7	28.3±6.8	35.0	8.0	35.0
<6	R	33.3	100.0	-	1.0	0.0	-	-	-	-
Lippia scaberimma:										
<6	A	49.5±25.5	41.7±41.7	-	-	33.3±33.3	26.8±4.4	25.0	18.0	25.0
<6	C	10.0	0.0	-	-	0.0	-	-	-	-
<6	C1	40.0	100.0	-	1.0	20.0	-	3.0	-	-
<6	D	45.7±36.1	100.0	-	-	38.9±38.9	21.1±1.7	15.0	15.0	15.0
<6	R	10.0	100.0	-	-	0.0	-	-	-	-
Monsonia burkeana:										
<6	C1	8.0	100.0	-	1.0	100.0	-	3.0	-	-
<6	D	8.0	0.0	-	-	0.0	-	-	-	-
Mundulea sericea:										
<6	A	25.0	100.0	-	0.0	0.0	-	-	-	-
<6	C	24.0	100.0	-	1.0	16.7	-	2.0	2.0	2.0
>6	D	100.0	26.0	-	-	26.0	-	3.5	-	-

OF VIABLE SEEDS IMBIBITION:						GERMINATION:				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
>6	E	100.0	100.0	-	-	20.0	24.3±2.6	20.0	15.0	20.0
>6	M	100.0	50.0	-	-	50.0	-	2.5	-	-
>6	N	100.0	94.0	-	-	94.0	-	2.5	-	-
>6	O	100.0	100.0	-	-	100.0	-	2.5	-	-
Pollichia campestris:										
<6	A	16.7	50.0	-	-	0.0	-	-	-	-
<6	C1	76.0	100.0	-	1.0	26.3	-	3.0	-	-
<6	D	23.8±7.2	4.5±35.5	-	-	64.5±35.5	16.5±5.5	16.0±6.0	16.0±6.0	16.0±6.0
<6	R	9.1	100.0	-	1.0	100.0	-	2.0	-	-
Rhus lancea:										
<6	A	40.0	100.0	-	-	0.0	-	-	-	-
<6	C	76.0	100.0	-	1.0	0.0	-	-	-	-
<6	D	40.0	100.0	-	-	50.0	28.0±0.0	28.0	28.0	28.0
>6	E	79.2	100.0	6.0±0.0	6.0	73.7	17.7±3.6	6.0	6.0	12.0
>6	F	82.5	100.0	6.0±0.0	6.0	81.8	23.2±2.2	18.0	6.0	22.0
>6	G	95.9	95.2	6.0±0.0	6.0	90.5	28.9±2.1	25.0	12.0	25.0
>6	H	79.2	100.0	6.0±0.0	6.0	68.5	26.3±2.4	22.0	12.0	25.0
>6	I	92.0	100.0	1.0±0.0	1.0	60.9	11.3±0.8	10.0	8.0	10.0
>6	L	100.0	100.0	1.0±0.0	1.0	12.0	11.0±2.1	11.0	8.0	10.0
>6	N	92.0	100.0	1.0±0.0	1.0	13.0	15.0±0.0	15.0	15.0	15.0
>6	P	92.0	100.0	1.0±0.0	1.0	13.0	15.0±0.0	15.0	15.0	15.0
>6	Q	96.0	100.0	1.0±0.0	1.0	0.0	-	-	-	-
>6	R	63.6	100.0	-	1.0	0.0	-	-	-	-
Solanum incanum:										
<6	C	81.5±18.5	50.0±50.0	-	1.0	50.0±50.0	-	1.0	-	-
<6	D	100.0	2.3±2.3	-	-	0.0	-	-	-	-
<6	R	100.0	100.0	-	1.0±0.0	100.0	-	2.0±0.0	-	-
Triumfetta sonderi:										
<6	A	41.7	0.0	-	-	0.0	-	-	-	-
<6	C	40.0	100.0	-	1.0	0.0	-	-	-	-

OF VIABLE SEEDS										
IMBIBITION:						**GERMINATION:**				
Seed Age (mths)	**Treat Code**	**% Viability (of intact seeds)**	**% Imbibed**	**Mean days to Imbibition**	**Peak Imbibition**	**% Germination**	**Mean days to Germ.**	**Peak Germ. (days)**	**Germ. Lag (days)**	**t50 (days)**
<6	D	41.7	20.0	-	-	20.0	30.0±0.0	30.0	30.0	30.0
<6	R	42.9	100.0	-	1.0	0.0	-	-	-	-
Ziziphus mucronata:										
<6	A	71.3±4.7	71.1±28.9	2.4±0.2	2.0	24.0±13.5	4.8±0.2	5.0±0.0	4.0±1.0	5.0±0.0
<6	B	100.0	100.0	-	-	10.0±4.5	-	7.0	7.0	7.0
<6	C	72.0±4.0	100.0	-	1.0±0.0	0.0	-	-	-	-
>6	E	91.7	100.0	2.0±0.0	2.0	100.0	7.5±0.5	7.5	2.0	7.5
>6	F	70.0	100.0	2.0±0.0	2.0	100.0	8.8±0.3	9.0	3.0	9.0
>6	G	70.8	100.0	1.0±0.0	1.0	100.0	9.7±0.6	12.0	6.0	12.0
>6	H	87.5	100.0	1.0±0.0	1.0	100.0	8.6±0.5	12.0	6.0	9.0
>6	I	88.0	0.0	1.0±0.0	1.0	100.0	3.1±0.2	4.0	2.0	2.0
>6	K11	100.0	100.0	1.0±0.0	1.0	65.0	6.7±0.8	9.0	3.0	9.0
>6	K12	100.0	100.0	1.0±0.0	1.0	45.0	5.7±1.1	3.0	1.0	3.0
>6	L	100.0	100.0	1.0±0.0	1.0	100.0	4.4±0.5	4.0	2.0	4.0
>6	N	76.0	100.0	1.0±0.0	1.0	78.9	9.7±0.5	9.0	4.0	9.0
>6	P	100.0	88.0	4.0±0.0	4.0	40.0	8.0±1.0	9.0	4.0	9.0
>6	Q	92.0	100.0	1.0±0.0	1.0	100.0	5.7±1.0	4.0	2.0	9.0
Ziziphus zeyheriana:										
<6	A	70.6	100.0	-	-	100.0	19.3±3.0	26.0	3.0	26.0
<6	C	88.0	100.0	-	0.0	0.0	-	-	-	-

Appendix 1. List of species for which seed fate was assessed, and for selected species, viability and germination.

Anacardiaceae:
Rhus lancea L.f.
Rhus pyroides Burch. var. *pyroides*
Asclepiadaceae:
Asclepias fruticosa L.
Asparagaceae:
Asparagus laricinus Burch.
Asteraceae:
Aster harveyanus Kuntze
Athrixia elata Sond.
Berkheya setifera DC.
Gazania krebsiana Less. ssp. *serrulata*
Helichrysum nudifolium (L.) Less.
Helichrysum rugulosum Less.
Lopholaena coriifolia (Sond.) E. Phillips & C.A. Sm.
Nidorella hottentottica DC.
Nolletia rarifolia (Turcz.) Steetz
Senecio scitus Hutch. & Burtt Davy
Stoebe vulgaris Levyns
Celastraceae:
Gymnosporia polyacantha (Sond.) Marais
Cucurbitaceae:
Acanthosiscyos naudinianus (Sond.) C. Jeffrey
Coccinia sessilifolia (Sond.) Cogn.
Cucumis myriocarpus Naudin ssp. *myriocarpus*
Ebenaceae:
Diospyros lycioides Desf. ssp. *lycioides*
Diospyros whyteana (Hiern) F. White
Euclea crispa (Thunb.) Guerke var. *crispa*
Euphorbiaceae:
Clutia monticola S. Moore
Fabaceae:
Acacia erioloba E. Mey
Acacia hebeclada DC. ssp. *hebeclada*
Acacia hereroensis Engl.
Acacia karroo Hayne
Acacia robusta Burch. ssp. *robusta* (E.Mey.) Brenan
Elephantorrhiza elephantina (Burch.) Skeels
Indigofera adenoides Baker f.
Mundulea sericea (Willd.) A. Chev.
Sutherlandia frutescens (L.) R. Br.
Geraniaceae:
Monsonia burkeana Planch. ex Harv.
Illecebraceae:
Pollichia campestris Aiton
Lamiaceae:
Leonotis leonurus (L.) R. Br.
Salvia verbenaca L.
Mesembryanthemaceae:
Carpobrotus edulis (L.) L. Bolus
Delosperma herbeum N.E.Br.
Pedaliaceae
Dicerocaryum eriocarpum (Decne.) Abels
Ranunculaceae:
Clematis brachiata Thunb.
Rhamnaceae:
Ziziphus mucronata Willd. ssp. *mucronata*
Ziziphus zeyheriana Sond.
Solanaceae:
Solanum incanum L.
Tiliaceae:
Grewia flava DC.
Triumfetta sonderi Ficalho & Hiern
Verbenaceae:
Lippia scaberrima Sond.

Appendix II. Key to treatments and media used for seed germination

All seeds were removed from fruit and nuts prior to treatment. Seeds were maintained on replicate batches of media for 14, 22 and 45 days, and all incubations were carried out at a temperature of 30°C. Seeds not germinated after 14, 22 and 45 days were assessed for viability using the Tetrazolium test.

Code	Seed treatment	Germination media	Photoperiod (hours light & dark)
A	None	Moist ash-free filters	24Dark
D	None	Moist ash-free filters	14Light,10Dark
B	Scarification: heat-point method	Moist ash-free filters	14Light,10Dark
E	None	Acid-leached river-sand	14Light,10Dark
F	10 minutes of plant-derived smoke	Acid-leached river-sand	14Light,10Dark
G	20 minutes of plant-derived smoke	Acid-leached river-sand	14Light,10Dark
H	30 minutes of plant-derived smoke	Acid-leached river-sand	14Light,10Dark
I	Heat-point method for <2 seconds	Acid-leached river-sand	14Light,10Dark
J11	Heat-point method for <2 seconds	Milled compost	14Light,10Dark
J12	Heat-point method for <2 seconds, then imbibed in aerated water for 16 hrs	Milled compost	14Light,10Dark
K11	None	Milled compost	14Light,10Dark
K12	Imbibed in aerated water for 16 hrs	Milled compost	14Light,10Dark
L	Immersed in hot water (94°C) for 30 sec's	Acid-leached river-sand	14Light,10Dark
M	Immersed in hot water (94°C) for 60 sec's	Acid-leached river-sand	14Light,10Dark
N	Immersed in hot water (94°C) for 120 sec's	Acid-leached river-sand	14Light,10Dark
P	Immersed in hot water (94°C) for 300 sec's	Acid-leached river-sand	14Light,10Dark
O	Immersed in hot water (94°C) for 30 sec's, subsequently un-imbibed seeds immersed up to 3 more times (at 5-day intervals)	Acid-leached river-sand	14Light,10Dark
N1	Immersed in hot water (94°C) for 60 sec's, subsequently un-imbibed seeds immersed up to 3 more times (at 5-day intervals)	Acid-leached river-sand	14Light,10Dark
C1	Imbibed in aerated water for 24hrs	0.1% tetrazolium chloride (aq)	24Dark for up to 3 days
Q	None, entire seed placed in media	0.1% tetrazolium chloride (aq)	48Dark, followed by 14Light,10Dark for 33 days
C	Imbibed in aerated water for 24hrs, then cut	0.1% tetrazolium chloride (aq)	24Dark for up to 3 days
R	Stored wet for 30 days in dark, then cut into 2 halves.	0.1% tetrazolium chloride (aq)	48Dark for up to 3 days