THE DEPLETION OF WEED SEEDS IN THE SOIL SEED BANK

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ABSTRACT

The fate of weed seeds in the soil seed bank depends on the processes of emigration, desiccation, predation, and germination. We summarise an ongoing trial on multiple tropical weed species that investigates the emergence of seedlings (successful germination) at a field research site. Intact fruiting structures were placed enclosed in wire mesh cages, on two different soil surfaces and with two different ground covers, and the emergence of seedlings was regularly recorded. By understanding the processes determining the fate of seed, practitioners can plan the duration and timing of control activities. Emergence is still being recorded from most of the seed lots, and the trial demonstrates the persistence that follows a large single reproductive episode.

Keywords: tropical, seed bank, persistence, depletion.

INTRODUCTION

In the absence of seed input, seed persistence is the result of four potentially interacting processes, emigration, desiccation, predation, and germination, which were reviewed by Long *et al.* (2015). Emigration is the loss of seeds to another site by dispersal and in the case of weeds should be avoided. Desiccation occurs when seeds cannot maintain physiological processes and are rendered unviable, often by a breakdown by the seed coat. Predation is the destruction of seeds by micro and macroscopic fauna or fungi and can lead to desiccation. Germination is where varying proportions of seeds germinate and either establish as seedlings or die.

This paper reports on an ongoing study recording the emergence of seedlings, that have germinated from fresh intact fruit or pods in field enclosures in north Queensland. Progressively since 2015, a trial has been conducted in wire mesh enclosures (cages) to prevent loss (emigration) but to study the timing, intensity, and duration of germination events which result in emergent seedlings of seven weeds. Once each seed lot is exhausted, the total proportion of the viable (surface sown) seed bank that successfully germinated to produce seedlings will be determined.

MATERIALS AND METHODS

Weeds species included in 2015-2016 were *Vachellia nilotica (*prickly acacia*)*, *Leucaena leucocephala (*Leucaena*), Ziziphus mauritiana* (chinee apple*), Prosopis pallida (*mesquite*)* and *Azadirachta indica* (neem tree). The neem tree and chinee apple were exhausted and were replaced with *Argyreia nervosa* (Elephant ear vine) in 2021 and *Parkinsonia aculeata* (Parkinsonia) in 2023, respectively. The trial is located at the Tropical Weeds Research Centre in Charters Towers, north Queensland and is a split plot design with four replicates for each species. The main treatment is soil type (alluvial river loam and clay), and the sub treatment is pasture cover (present and excluded). Bebawi *et al*. (2015) details the trial location and treatments. Each plot consisted of a mesh enclosure (0.9 m wide * 0.9 m long * 0.4 m high). Mature pods/fruits were collected at the maximum production time for each respective weed species. The equivalent of 500 fresh mature seeds within intact pods/fruits of each species were then scattered on the ground surface within each plot. To mimic the fall of leucaena seed from split plant-borne pods, those seeds were not placed in pods. Seedling emergence within each plot was recorded and seedlings removed every two weeks. The trial concluded for individual species when no emergence was recorded over three wet seasons. The sow dates and duration of each species emergence is given in the results. For each species, the total seedlings and % viable seed emergence to the 8/6/23 was analysed in Genstat as a split plot design. Only significant treatment effects or interactions are mentioned in the results.

Prior to placement in the cages, a subsample of 200-500 seeds of each seed lot were tested for initial viability. Seeds were placed in petri dishes on top of filter paper and moistened with distilled water and placed in a Thermoline® incubator set at a 30/20°c 12/12 hr diurnal cycle. Seed germination was recorded. Scarification or tetrazolium testing was undertaken on ungerminated seeds after three weeks. The data is presented as the total % emergence of the approximate viable seed totals (maximum 2000) summed across the four replicates of each combination of treatments.

Daily rainfall, minimum and maximum temperatures were extracted for grid mid-point at Latitude**,** -20.10 and Longitude**,** 146.25, (State of Queensland, 2023). Daily data was converted to fortnightly temperature averages and total rainfall to match the cage monitoring frequency.

RESULTS

A summary of the weather (Figure 1) and emergence data to 8/6/23 follows.

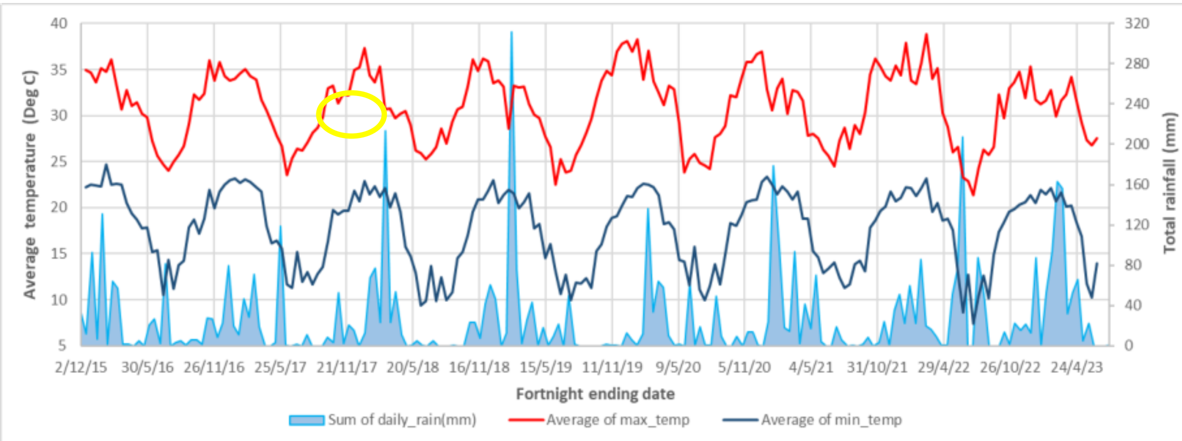

Figure 1. Average minimum and maximum daily temperatures for each fortnight and total fortnightly rainfall from 1/12/2015 to 30/6/2023 (State of Queensland 2023).

The mild temperatures (daily maximums around 30°C) and favourable rainfall conditions in early 2018 (yellow circle- Figure 1) lead to a noticeable spike in prickly acacia, mesquite and Chinee apple seedling emergence around the fortnight ending 8/3/18.

Prickly Acacia

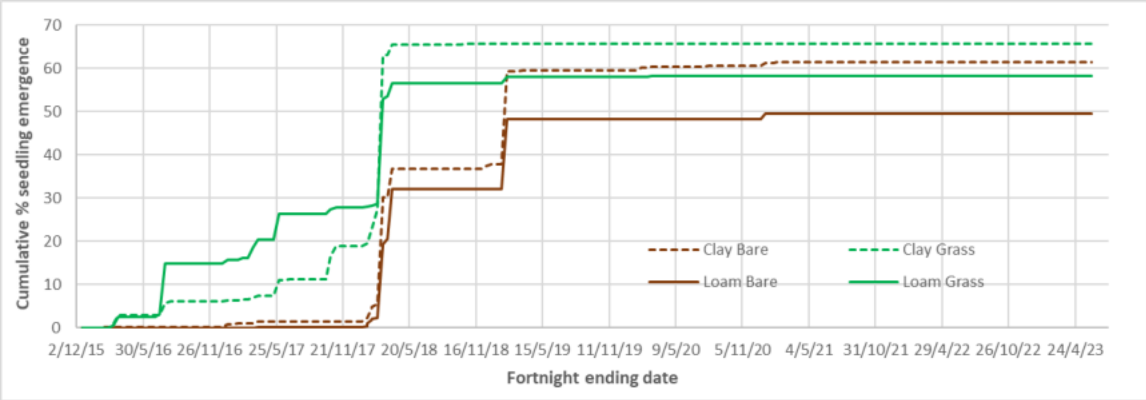

Figure 2. Cumulative seedling emergence of Prickly acacia between fortnights ending on 14/12/15 and 8/6/23, as a % of approximately 1696 viable seeds per treatment.

Seedling emergence commenced earlier in the grassed plots with mid-year rainfall in 2016, not earlier in that year. The greatest emergence was recorded across all treatments in January to April 2018, particularly the fortnight ending 8/3/18. A flush of emergence was also recorded in the bare plots in the fortnight ending on the 7/2/19. By 8/6/23, an average of 58.8% of approximately 1696 viable seeds per treatment had germinated, with no significant differences in the treatments means or interactions. These plots are still being monitored and the last recorded seedling was on the 16/2/23, which is 7.2 years after the pods were placed in the cages. One seedling was also recorded in 2022 (fortnight ending 17/2/22).

Leucaena

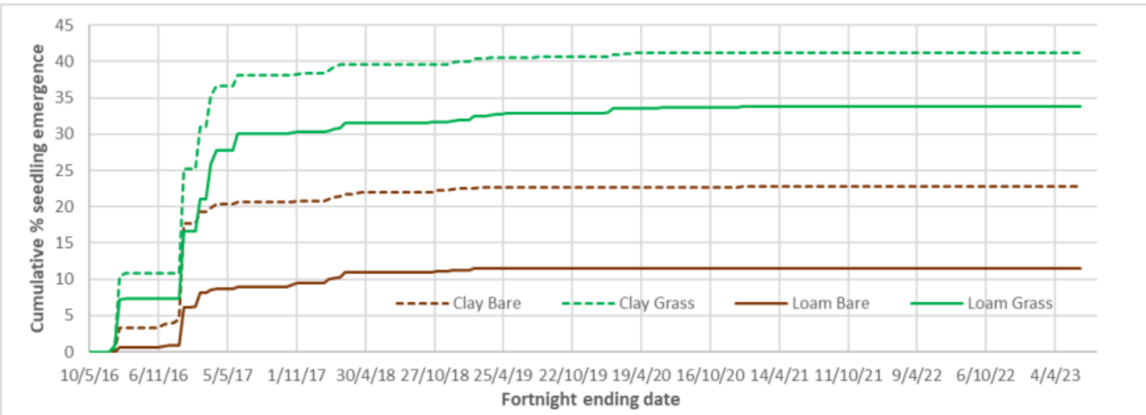

Figure 2. Cumulative seedling emergence of Leucaena from fortnights ending on 4/5/16 to 8/6/23, as a % of approximately 1816 viable seeds per treatment.

Seedling emergence commenced in the grassed plots in July 2016 and was highest in all treatments in early to mid-2017. There was a significant ground cover effect in the % emergence to 8/6/23, with an average of 17.2% of seeds emerging in bare plots and 37.6% in grassed plots. These plots are still being monitored and the last recorded seedling was on the 6/1/22, which is 5.7 years after the pods were placed in the cages.

Mesquite

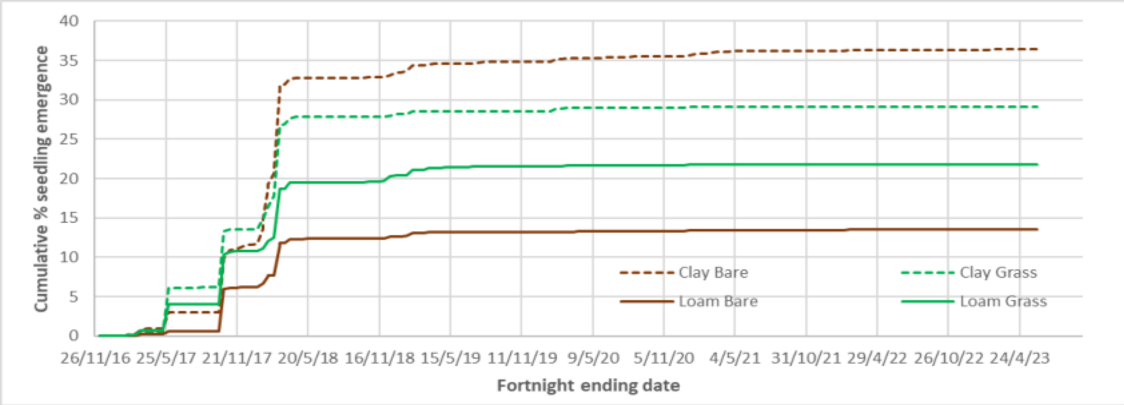

Figure 3. Cumulative seedling emergence of mesquite between fortnights ending on 8/12/16 and 8/6/23, as a % of approximately 1832 viable seeds per treatment.

Seedling emergence commenced in early to mid-2017, with several peaks (19/10/17 and 8/3/18) and most emergence between October 2017 and April 2018. A soil effect was evident with19.3% emergence in loam plots and 35.4% in clay plots. There was also a difference between emergence in the bare loam (14.8%) and bare clay (39%) plots. These plots are still being monitored and the last recorded seedlings (3) were on the 16/2/23, which is 6.2 years after the pods were placed in the cages.

Chinee apple

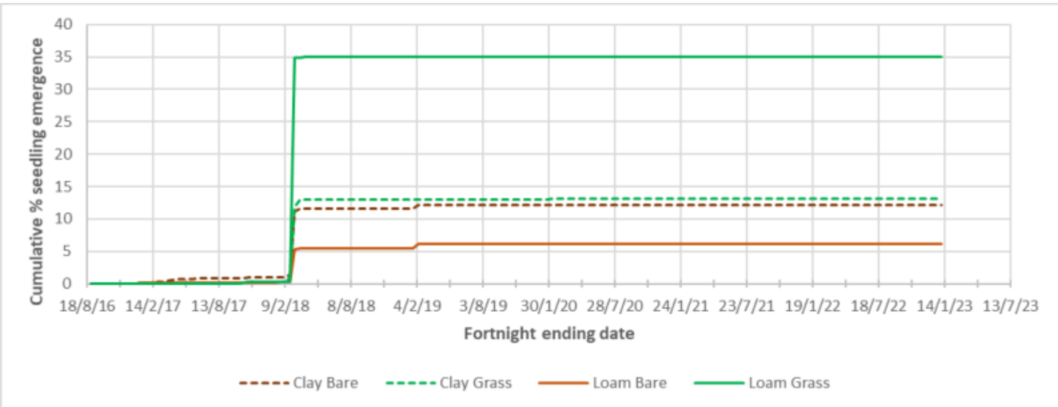

Figure 4. Cumulative seedling emergence of chinee apple seedlings between fortnights ending on 28/8/16 and 5/1/23, as a % of approximately 1168 viable seeds.

The vast majority of chinee apple seedling emergence was recorded in the fortnight ending 8/3/18. There was a significant interaction between soil and cover factors in the % emergence to 8/6/23 data. An average of 35.0% emergence was recorded in grassed loam plots and 6.2% in bare loam plots. There were also significant differences between emergence in the grassed (24.1%) and bare (9.2%) treatments. Seedlings (3) were last recorded on the 6/2/20, which is 3.4 years after the fruit were placed in the cages. Parkinsonia pods were placed in these cages three years later, and after a subsample of the remaining intact chinee apple seed recorded nil viability, but any chinee apple seedlings will still be noted if they emerge.

Neem tree

Approximately 936 viable neem tree seeds in fruit were placed in cages on the 11/2/16 and the last recorded emergence was on the 21/4/16, after 5.8 months. A second batch of seed (1518 viable) was placed in the cages on the 21/2/17 and the last seedling was recorded on the 2/11/17 after 8.4 months. Across both placement dates there was no emergence in the bare plots and 2.8% of the viable pools emerged in the grassed plots. Seed of a different species was added to these plots on 19/8/21.

Elephant ear vine

Approximately 1420 viable elephant ear vine seeds were placed, in fruit, in the cages on the 19/8/21. To 8/6/53 there has been low emergence in the bare plots (2.2%), compared to 23.1% of seedlings emerging in the grassed plots. There was emergence recorded on the 25/5/23 and this seed lot is still being monitored, as emergence is expected to continue.

Parkinsonia

The equivalent of 1740 viable parkinsonia seeds were placed, still in pods, in the cages on the 5/1/23. To date there has been low emergence in the grass plots (0.1%), compared to 1.8% of seedlings emerging in the bare plots to 8/6/23. Seedlings were recorded on the 25/5/23 and this species is still being monitored as emergence is expected to continue.

DISCUSSION

This trial shows the proportion of the seeds germinating, the duration of emergence from surface broadcast pods/fruit and the local triggers for germination events. The approximate number of viable seeds in each cage is known, so as each species seed is exhausted a proportion of the seed can be attributed to germination and successfully reaching a detectable seedling stage. Emergence to the seedling stage accounted for less than 3% of the viable neem tree seeds in grassed plots. While chinee apple emergence accounted for 16.7% of the overall viable seed, with obvious treatment differences. To date, over 58% of the viable prickly acacia seeds have emerged over seven years since sowing. The overall figures show large differences in the emergence of different weeds. For the weeds where emergence has concluded, the remainder of the seed is presumably lost to processes of desiccation, predation, or unsuccessful germination.

Weed practitioners have little capacity to manage ground cover across natural and grazing land settings. However, it was observed that the prickly acacia pods broke down sooner in the grassed than the bare treatments. This is presumed to have contributed to the earlier recording of seedling emergence in those plots. Leucaena and mesquite showed a similar pattern with earlier emergence in grass plots higher than bare plots, although the leucaena was not placed in pods. Similarly, the initial seedling establishment of elephant ear vine was 10x higher in the grassed than bare plots. Time will tell if the parkinsonia emergence in the grassed plots ‘catches up’ to the initial emergence recorded in the bare plots. Retaining surface moisture amongst the grass plots appears to influence the breakdown of the fruit and subsequent emergence patterns. The regular monitoring of these plots does indicate the mechanism of the different emergence rates on bare and grassed plots. Outside of cultivated areas, it is not desirable to maintain bare landscapes. Further seedling survival may also be lower with a competitive ground cover.

Over the course of the regular monitoring, seeds have been released from the fruit and incorporated into the soil profile. Natural weed seed burial can be slightly higher in a loam soil, than a silty clay soil, and notably higher in sandy soil and with increasingly smaller seeded weeds (Benvenuti 2007). There were significant soil effects in the emergence patterns of chinee apple (favoured grassed/loam) and mesquite (favoured clay) seedlings. These emergence and burial patterns may be applicable to the local management of infestations of these weeds.

Whilst weed seeds respond to the environment to maximise the chances of establishing to mature plants, emergence does not equal establishment. At some fortnightly monitoring intervals, seedlings were noted as being stressed when removed and seemed unlikely to survive further dry and or hot conditions. This trial did not investigate establishment and growth beyond the seedling stage. Further analysis of each weed's emergence patterns will probe the contribution of weather events to the timing and width of the emergence windows. Which will help to identify follow up control windows to prevent seedlings maturing and dispersing.

The need for land managers to prevent fresh seed input is highlighted by the multiple years over which most weeds emerged after a single input of seed onto the soil surface. From a single seed addition event prickly acacia emergence has continued for at least seven years, or one year's seed has given seven years weed, so far!

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