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# General Observations of the Germination Requirements of New Zealand Native Flora

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**Summary**

This paper is of interest to nurseries that collect and propagate native seed. Totara Glen Nurseries is primary a native plant supplier to New Zealand territorial authorities and infrastructure projects. Some 99% of seed is collected, processed and stored by us – and 95% of our plants are grown from seed. Challenges in dormancy and seed propagation systems - appropriate for seedling production of our select, New Zealand native plants and environs are discussed.

## INTRODUCTION

This report covers general observations for germination requirements of New Zealand native plants. I include information from a seminal paper by Fountain and Outred (1991) on germination requirements of New Zealand native plants – which provides some excellent discussion points and observations. I also include my personal observations from sexually propagating native plants at Totara Glen Nurseries. Types of seed relative to seed germination, germination techniques – including the possibility of fire ecology in some New Zealand native seed – as well as increased infertility issues of native seed during the past 20-years are addressed.

There is a range of delayed seed germination phenomena in New Zealand, which is relevant to industry professionals who collect seed from the wild in other parts of the world.

Delayed germination is a critical factor in many New Zealand flora for the survival of many plant species. This could be because of the following environmental factors.

- Avoiding heavy frost periods. Low temperature and associated winter desiccation have a known effect in seedling survivability, both in the wild and in the nursery environment.
- Avoiding extensive drought periods (and ephemeral/ short-term environmental conditions), i.e. e.g. some of our native rushes and cultivars. A major abiotic factor in seedling loss after germination is summer moisture deficit periods, i.e. drought.
- Getting suitable light requirements for seed germination. It is often noted that once a large climatic plant species succumbs to either age or windfall – opening up large ground areas to sunlight - germination of some native species is dramatically increased.
- Setting up ecological seed banks via delayed germination.
- Combinations of the above.

**Totora Glen Nurseries**

Totara Glen Nurseries is primary a native plant supplier to New Zealand territorial authorities and infrastructure projects (**Fig. 1**).

**Figure 1.** Totara Glen Nurseries, Palmerston North, Manawatu, New Zealand

Some 99% of seed is collected, processed and stored by us – and 95% of our plants are grown from seed (**Fig. 2**). Most seed are sourced from the lower North Island, Taupo to Wellington, with some seed collected from the Auckland area and the South Island (**Fig. 3**).


**Figure 2.** Seed collection of native New Zealand plants and their subequent seedling production at Totara Glen Nurseries.


**Figure 3.** Palmerston North, Manawatu, New Zealand – North Island; see arrows.

In understanding germination processes, it is appropriate to discuss types of germination in respect to New Zealand flora.

### Vivipary

Vivipary is the germination of seed while still attached to the parent plant. An example of this is *Pachystegia insignis*.

The propagules are pregerminated on mother plants - and naturally dispersed with an emergent root and shoot system (**Fig. 4**).


**Figure 4.** Vivipary of *Pachystegia insignis* with propagules pregerminated (arrow) while still attached to the mother plant – allowing dispersion with an emergent root and shoot system.

### Recalcitrance

This word is defined as "obstinately defiant of authority or restraint" or "difficult to manage or operate and not responsive to treatment". Many native species exhibit recalcitrance. Recalcitrant seeds lose viability after drying, while orthodox seeds tolerate maturation drying.

Germination in recalcitrant seeds must proceed soon after maturity – or seeds must be stored under conditions that prevent drying (Davies, et al. 2018). Highly recalcitrant seed are intolerant of tissue moisture levels that drop below 10-12 percent. There are many examples in native New Zealand flora: Kahikatea, Pukatea, Kauri, Griselinia, beech, etc. **(Fig. 5**).

**Figure 5.** Some examples of native New Zealand species with recalcitrant seed include: Kahikatea, Pukatea, Kauri, and Griselinia,

### Quiescent Seed

Quiescence is a period of inactivity. Most native seeds enter a quiescent stage during maturation associated with desiccation/ maturation drying. If seed is dried excessively, it may die or go into double dormancy (more than one dormancy requirement will need to be satisfied for seed to germinate). This is most likely a survival mechanism related to drought -and waiting for more optimal soil moisture conditions to assure seed germination and seedling survivability. Drought is the biggest factor in seedling death (survivability!) in the New Zealand natural forest ecosystem. Quiescence is distinct from dormancy where specific dormancy/priming treatments are required to initiate embryo growth. Examples are Manuka, Kanuka, Phormium, Nikau, forest margin species - *Pittosporum eugenioides*, *Pittosporum crassifolium*, and some Coprosma species.

### Dormant Seed

Seeds of many species require an environmentally imposed stimulus to initiate germination. This could be chilling (stratification), light (duration, photoperiod) or even freezing. This is generally related to biochemical inhibitors (***internal dormancy***). Also, impervious seed coats which restrict either water or gas exchange cause ***external dormancy*** (Davies, et al., 2018).

### Low Temperature Dormancy

A requirement of cold-period stratification to ensure germination is a characteristic of many New Zealand native seeds. My experience is that a stratification period not only ensures germination in some species, but it also promotes more uniform germination; this is critical for commercial medium- to large-scale native plant production systems - managing logistics of scheduling seedling production during the calendar year. In my experience, this reaction to temperature is very dependent on the ecological zone the seed was sourced from. There is a large difference in some species in germination time relative to the eco-source (provenance) of the seed. In general, the colder the eco-source area, the longer the germination period. Examples include *Pittosporum tenuifolium* and Podocarps (plum pine).

### Light Induced Dormancy

The amount of light (irradiance) and the daylength (photoperiod) affects seedling emergence. My observations indicate that daylength, as well as temperature affect germination, i.e. Spinifex (coastal grass). Seeds sown in late autumn through late winter, often germinate in midspring. I suspect this is the case for many native seedlings, such as *Melicytus ramiflorus*, *Astelia* sp., *Pittosporum tenuifolium* and *Pittosporum ralphii*.

There are relationships of habitat to light requirements. Shaded habitats where light is enriched in green and far-red wavelengths, drive the light quality-sensing pigment phytochrome from an 'activating' state which is known to promote germination, i.e. recently open canopy situation or bush edge situations. Red light promotes seed germination, while blue light and a low red/far−red ratio condition inhibits seed germination.

### Chemical Induced Inhibitors

At least 20 inhibitory compounds have been identified in seed, suggesting that these are also prevalent in some native seed. It is common for native plant propagators to carry out prolonged washing of seed (leaching), to overcome certain dormancies – and promote germination times, i.e., *Pittosporum eugenioides, Cordyline australis, Aristotelia serrata* and *Melicytus ramiflorus*. Past work has been done to show that the fleshy fruit layer of *Pseudopanax crassifolius* contains an inhibitory substance. Reasons for this could be to initially inhibit germination until sufficient rains and soil moisture occurs. Prolonged rain events will leach inhibitory compounds from the seed.

### Rudimentary Embryos

Rudimentary embryos require further embryo development after the seed has been detached from the parent plant. Typically, there are double dormancy requirements where seed is sown to let the embryo further develop – and then a secondary dormancy condition must be met, i.e. cold-moist stratification for germination to proceed. Examples include conifers such as Miro, Kahikatea and Rimu (**Fig. 6**).

**Figure 6.** Rudimentary (underdeveloped) embryos require further embryo development after the seed has been detached from the plant, i.e. conifers such as Miro, Kahikatea and Rimu.

### Seed Coat Imposition of Dormancy (External Dormancy)

Seed coat imposition is found in New Zealand native legumes, and as such germination is inhibited until seed coat disruption/rupturing/scarification has occurred.

Examples include *Sophora* sp. and native brooms. See seed trials of *Sophora microphylla* experiencing external dormancy - requiring scarification **(Table 1 and Fig.** 7**).**

**Table 1.** Seed trials of *Sophora microphylla* experiencing external dormancy.

| |
|---|
| Sophora microphylla Sth Kopuatai Peat Dome Waikato 1992 ---- Sown 19th March Germinated |
| Sophora microphylla Trotters Gorge South Island 1994 ----- Sown 19th March Not Germinated Yet |
| Sophora microphylla Gore South Island 1996 ----- Sown 19th March Germinated |
| Sophora microphylla Hamner Springs South Island 2000 --- Sown 19th March Germinated |
| Sophora microphylla Haast South Island 2001 ---- Sown 19th March Not germinated yet |

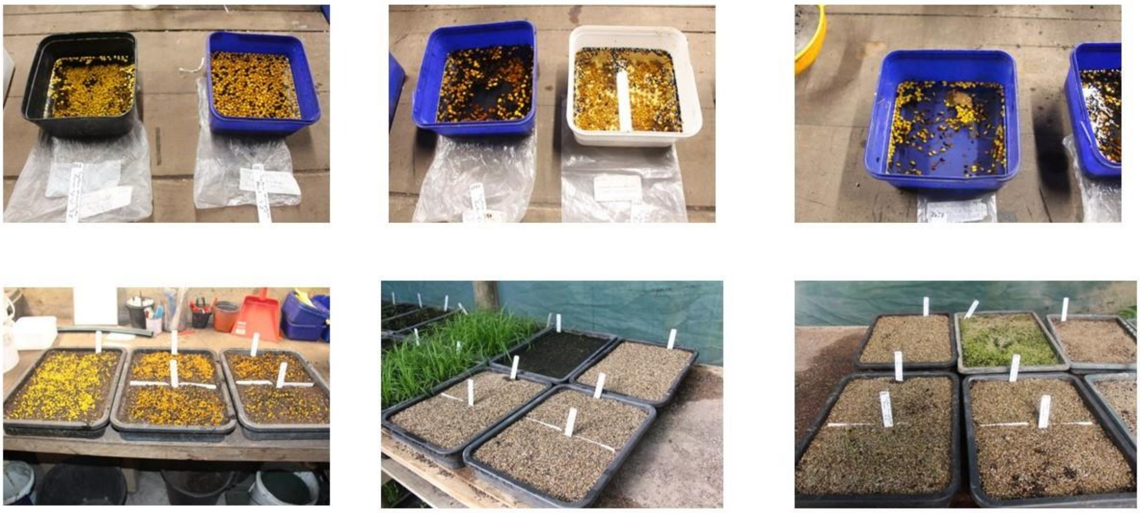

**Figure 7.** Seed trials of *Sophora microphylla* experiencing seed coat external dormancy.

**Heat/Smoke Promotors of Germination**

Do New Zealand Native Plants have an existing or hereditary fire ecology? Have we inherited this from seed coming over from Australia? Exposure to smoke has been shown to improve germination of Australian native species previously thought to be difficult or impossible to germinate (Dixon et al., 1995). I have noted that liquid smoke enhances germination of some New Zealand native species. In an IPPS publication, Bachman (2009) reported on enhanced seed germination with liquid smoke. Possible examples include Pomaderris, Spinifex, Sophora, Whau, and native orchids.

**Ectomycorrhizal Fungi**

These host plant associations are known particularly in Native Beech. Some 42 mycorrhizal genera are recorded in association with *Nothofagus* sp. (southern beech), *Leptospermum* (tea trees) and or Kunzea alone. We know they have an influence in seedling growth, so why not germination success as well? Mycorrhiza have been reported to enhance both nursery propagation and production systems (Davies, 2008).

**Climate Change & Seed Viability**

Is climate change affecting the viability of our Native Seeds? There have been large population declines in native insects. We know that pollination by native insects is an important part of native flora ecology. Reduction in insect pollinators could be indirectly affecting the viability of some native seeds. Many native nursery specialists in operation for 20 plus years, have experienced reducing viability of some native seeds. Examples are Spinifex (coastal grass) and Pittosporum species.

**Record Keeping**

Keeping accurate, detailed records of seed provenance, germination treatments, and observation of seed germination trials - is critical for the commercial seed propagation (**Fig. 8**). And modern technology allows information to be digitized (Davies et al., 2018).

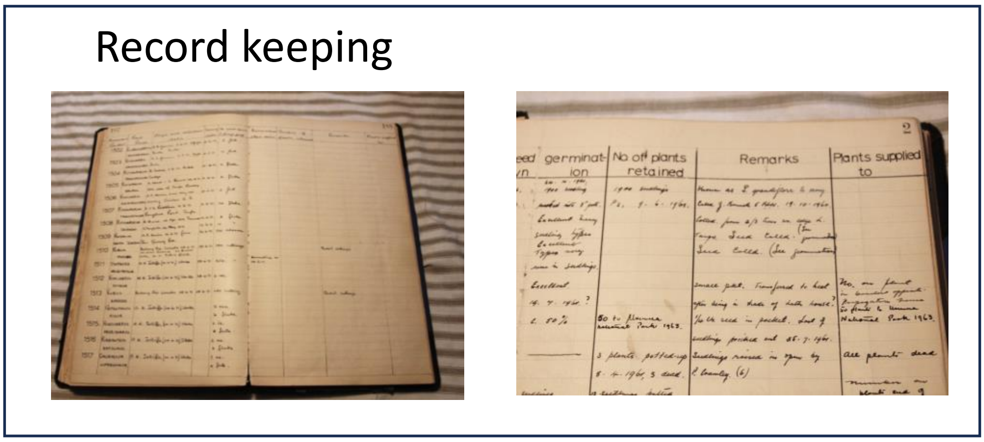


**Figure 8.** Accurate, detailed records and observation of seed germination trials is critical for the commercial seed propagation.

## CONCLUSION

There is a huge variation in germination across New Zealand native flora. It is clear that once a strategy has been employed to engage germination (or break a dormancy) - there can be other environmental-genetic factors that affect select species germination systems, i.e. uniformity, production cycle period, etc. For smaller nurseries, fresh seed is best, but for larger nurseries where labor resources are closely managed - a clear strategy is needed to manage all the different variables of in play – from seed provenance to seed harvesting/processing to pre-germination to germination strategies. As previously stated, natural delayed germination is a critical factor in the survival of many plant species. Thus, better understanding how different seeds delay germination - helps develop more efficient germination strategies to efficiently unlock select dormancy requirements – to break dormancy – and ensure more uniform seed production systems.

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