Germination Experiments on Seeds of Some New Zealand Lowland Forest Species

Colin Burrows
Department of Plant and Microbial Sciences, University of Canterbury, Private Bag 4800, Christchurch

INTRODUCTION

Nurserymen know a lot about germinating the seeds of native species, but have not often recorded their knowledge. Other professionals with an interest in the subject have published some information, but there is still only a limited amount of detailed information in print on how to get seeds of plants of our native flora to germinate. A recent review of literature on seed germination relevant to New Zealand native plants (Fountain and Outred 1991) covered only 38 articles and 113 species.

About 10 years ago I decided to study seed biology of plants in South Island native forests. My aim was to improve our understanding of this vital phase in the forest regeneration process. Since 1989 I have published articles on seed germination, seed crops, dispersal, and seed predation in New Zealand Natural Sciences, Canterbury Botanical Society Journal, and New Zealand Journal of Botany.

Here I want to outline the methodology I use and some results of simple experiments on seeds collected fresh, from wild plants, in South Island locations, when fruit are ripe (summer, autumn) and placed in sets of conditions like those that they could experience in nature. Much can be learned from such studies — some of it may be useful to plant propagators.

METHODS

As fruit ripens dry capsules open, releasing seeds, and fleshy berries and drupes are eaten by birds. The seeds fall to the ground — they may be exposed on the surface, buried in litter, or deeper in the soil. They may remain moist, or dry out for short, or long periods. My experiments are aimed at simulating these varied conditions.

I place my seeds into the experiments — conducted in an unheated, partly shaded glasshouse — after simple pre-treatments. One treatment in fruit (Table 1) mimics the situation where whole fruit fall from the parent. For all other treatments the fruit tissues are removed and the cleaned seeds are soaked in tap water for about 24 h and sorted to exclude any that are damaged or empty, before being placed in the experimental conditions. Tap water is used for all the tests.

The conditions of the remaining five treatments — standard, dark, soil, dry, and buried — are noted in Table 1. Standard is a baseline for comparison of results of all other treatments, as the best results are usually achieved in it. The numbers of replicate samples of 25 seeds are small; even so the full range of tests requires at least 300 seeds and these numbers are sometimes hard to achieve. The consistency of results between replicates seems to justify the use of small samples; in a sense every seed constitutes a unit sample.

Table 1. The conditions of the treatments.

	Treatments	No. of replicates of 25 seeds
1	In fruit — left in fruit tissues. For all other tests fruit tissues are removed (not completely possible for drupes, achenes).	1 or 2
2	Standard — kept wet, on filter paper, in petri dishes in maximum available daylight.	4
3	Dark — same conditions, but kept in black plastic bags.Checked at about monthly intervals in darkroom under photographic safelight.	2
4	Soil — in small grooves in pasteurized potting soil in small plastic meat dishes, kept continually moist.	2
5	Dry — kept dry over winter (3-4 months), then put in conditions as for standard treatment.	2
6	Buried — buried 5 cm below soil surface in a plastic drain pipe cylinder 30 cm high. If seedlings do not appear seeds are unearthed after 1.5 years (approx.) and placed in conditions as for soil treatment.	1 or 2

Physiological programming of seeds begins while they are on their parent and continues up to the time they germinate, through responses of the living seeds to environmental cues (temperature changes, light quantity or quality, gas concentrations, moisture conditions). Whatever treatments we give, seeds are likely to modify their behaviour. This is the rationale for working with seeds taken straight from ripe fruit on their parents (or freshly fallen fruit picked from the ground in the case of tall trees like *Prumnopitys taxifolia*, matai, or *Laurelia novae-zelandiae*, pukatea). The same rationale applies to the use of experimental treatments resembling the conditions which the dispersed seeds could experience in nature. The only exception that I have employed is testing sets of hard-coated seeds such as those of *Sophora microphylla*, kowhai, *Calystegia tuguriorum*, panahe, *Dodonaea viscosa*, ake ake; or seeds with hard endocarp around them such as *Myoporum laetum*, ngaio, or *Elaeocarpus dentatus*, hinau, after cutting through the tough enclosing tissues.

The experiments are monitored about weekly, and watered as needed. Glasshouse maximum temperatures can rise to 34C in summer, but are mainly in the range 15 to 25C. Minimum temperatures descend to -4C in winter, but are mainly in the range 5 to 10C. Germinated seeds are removed and planted out in soil.

RESULTS

So far I have worked on about 90 species. I will discuss a few examples, to illustrate salient points (see Table 2).

In-fruit. In this treatment there is almost invariably nil or poor germination (for fleshy fruited species and some dry fruited species).

Standard. Best results are achieved in this treatment — usually 90% to 100% germination. Many species germinate, some quickly, some slowly, in summer, autumn or winter [e.g., *Griselinia*, *Kunzea*, *Coprosma*, and *Melicytus* (Table 2)]. This means that their seeds are not primarily dormant (cf. Bewley and Black,1982; Burrows, 1994). Other species exhibit different kinds of behaviour, in relation to the seasons. *Aristotelia serrata* seeds from some locations germinate relatively quickly in autumn, except for a small proportion which overwinter and germinate in the following spring. *Hoheria* seeds germinate over a short period in early spring. *Myrsine australis* seeds are slow to start and complete germination. Like those of *Hoheria* and the few late-germinating *Aristotelia* seeds they appear to require some cold treatment (i.e., exhibit primary dormancy). In some species, e.g., *Urtica ferox*, onga onga, the biochemical blocking which characterizes truly dormant seeds may need several cold winters to overcome it.

Other species have delayed germination for other reasons. *Hedycarya* appears to have immature embryos, which require a long period of time before they are ready to become activated. *Pseudowintera colorata*, horopito, seeds are like this too. Cold treatment does not seem to speed up the process. *Dodonaea* seeds, like those of *Sophora microphylla* or *Calystegia tuguriorum*, have very hard coats, resistant to microbial disintegration. The germination of their seeds, in natural conditions, only takes place when the coat is finally breached. In *Dodonaea* it can take 2 years or more and in *Calystegia* more than 5 years, before all seeds from a cohort germinate. Another cause of delay is the requirement, in *Rhopalostylis*, for relatively high temperatures, before the seeds germinate.

Dark. Seeds of nearly all species germinate in the dark but the process is slower than in the standard conditions. Exceptions are *Schefflera digitata*, (pate) *Weinmannia racemosa*, (kamahi), and *Coriaria sarmentosa*, (tutu) which fail to germinate.

Soil. There is usually poorer germination success than in the standard. The cause of this is unclear, but microbes and fungus gnats may be at least partly responsible. Trials of some more inert media are needed to test these ideas.

Dry. Seeds of some species (e.g., *Hedycarya, Rhopalostylis, Pennantia*) fail completely if dried for 3 to 4 months. Others (e.g., *Griselinia, Ripogonum*) are killed by 1 or 2 weeks. Dry seeds of several species (e.g., *Coprosma robusta, Aristotelia, Hoheria*) lose much viability, while others (e.g., *Kunzea, Melicytus, Fuchsia excorticata, Myrsine australis*) are relatively unimpaired, and germinate well when moistened.

Buried. There are three main patterns of response to this treatment (at a reasonably extreme depth to ensure that the gaseous environment is isolated from direct atmospheric influence).

a) Seeds of some species germinate underground but lack the energy to get shoots to the surface and seedlings die underground. To succeed they need to be buried more shallowly (according to their maximum potential hypocotyl length). It is interesting that species such as *Griselinia* and *Kunzea* appear to have no means of preventing themselves from germinating when in this inappropriate situation.

b) Others germinate underground and send shoots to the surface. This applies to relatively large-seeded species such as *Rhopalostylis*,

Table 2. Germination results for five treatments with seeds collected in summer and autumn.

Species	Standard			Dark	
	Period before germination (weeks)	Germination period (weeks)	Success (%)	Comments	Success (%)
Griselinia littoralis broadleaf	1	5	92	Slower than standard	96
Melicytus ramiflorus mahoe	1.5	4	99	Similar to standard	96
Kunzea ericoides kanuka	3.5	11	100	Slower than standard	86
Coprosma robusta karamu	2.5	9.5	90	Slower than standard	60
Aristotelia serrata wineberry	2.5	10 (a few seeds delayed until spring)	96	Similar to standard	86
Hedycarya arborea pigeonwood	4.5	13	100	Slower than standard	92
Dodonaea viscosa ake ake	9	59	98	Similar to standard	24
Hoheria angustifolia narrow-leaved ribbonwood	11	5	93	Slower than standard	88
Myrsine australis mapou	16	41	100	Slower than standard	42
Rhopalostylis sapida nikau	43	9	95	Slower than standard	84

Soil		Dry		Buried	
Comments	Success (%)	Comments	Success (%)	Comments	Success (%)
Slower than standard	72	Seeds die within 1-2 weeks of being dried	0	All germinate underground and die	0
Slower than standard	84	Germinate in 8 weeks	98	All seeds go dormant; many germinate when brought into light in second year	52
Slower than standard	76	Germinate in 4 weeks	92	All germinate underground and die	0
Slower than standard	92	Germinate in 12.5 weeks		Germinate underground and send shoots to surface over 2 years	80
Slower than standard	84	Germinate in 18 weeks	76	Most germinate underground and die; some go dormant and germinate when brought into light in second year	28
Slower than standard	98	Seeds die when dried	0	Germinate underground and send shoots to surface over 2 years	76
Slower than standard	76	Not done	-	Germinate underground and send shoots to surface over 2 years	80
Slower than standard	84	Germinate in 6 weeks	16	All germinate underground and die	0
Faster than standard	54	Germinate in 26 weeks	100	Germinate underground and send shoots to surface in first year	68
Slower than standard	28	Seeds die when dried	0	Germinate underground and send shoots to surface over 2 years	92

Corynocarpus, and *Beilschmiedia tawa*, and also to some relatively smaller-seeded species such as *Coprosma robusta*, *Dodonaea*, and *Myrsine australis*. The *Myrsine* actually germinates faster in the buried treatment than in the standard.

c) Others go dormant and remain so until they are brought into the light, where they germinate, usually with reduced percentage success. Among them are *Melicytus*, *Aristotelia*, *Macropiper excelsum*, and *Solanum laciniatum*. The secondary dormancy that is induced by burial means that these species could all form seed banks of more than 1 year's duration. Even for the species that send shoots to the surface from 5 cm depth some seeds must be dormant, because their seeds germinate over a period of 2 years. Dormancy may be induced by a CO_2, or ethylene-rich atmosphere.

CONCLUSIONS

I will not discuss the results at much more length; their significance will be evident, generally, to nursery people. It is as well to note, however, that the results are usually from one or two provenances of seeds from South Island locations. Seeds from Auckland or other localities may behave differently, to some extent. Also, in my earlier experiments (published briefly in the Canterbury Botanical Society Journal Vol. 27, 1993 and Vol. 29, 1995, and in more detail in the New Zealand Journal of Botany Vol. 33, 1995 and Vol. 34, 1996) I had not done the dry and burial experiments. Furthermore, some results from the earlier dark experiments are suspect, because the petri dishes were wrapped in aluminium foil, which eventually may have let in some light through small holes. I have repeated dark experiments for most of the species tested earlier, with light excluded by thick, black polythene. These are the results outlined here. In late 1996 in the New Zealand Journal of Botany Vol. 34, and in future accounts, the dry, burial, and new method for the dark treatment are reported.

Summing up some useful tips for anyone wanting to work with seeds of native forest species:

Best results are obtained with fresh seeds. It is wise to take fruit from plants that are fruiting heavily.

Fruit tissues must be removed. This applies to both fleshy and dry tissues and, after the seeds are cleaned, I soak them in tap water for 24 h. I have not yet found a simple way to remove the mucilage from *Pittosporum* seeds. Bacteria and fungi do this eventually, usually without harming the seeds.

Seeds of many species germinate well without cold treatment (unlike many Northern Hemisphere species). However, nursery people may wish to store seeds over winter and it is sensible practice to do this with the seeds kept moist, in a refrigerator. Chilling may cause seeds to become dormant, but little is known about this for New Zealand species.

Seeds of some species must be kept moist all the time. Others can be kept dry for a few months. Seeds of some species respond very well if buried about 2 cm (or more). I would recommend this for large-seeded species like *Corynocarpus* and *Beilschmiedia*, but it also works for other species, as noted in Table 2.

I am writing a booklet on this work and hope it will be ready towards the end of 1997.

LITERATURE CITED

Bewley, J.D. and **M. Black.** 1982. Physiology and biochemistry of seeds. Vol. 2. Springer Verlag, Berlin.

Burrows, C.J. 1994. The seeds always know best. N. Z. J. Bot. 32:349-363.

Fountain, D.W. and **H.A. Outred.** 1991. Germination requirements of New Zealand native plants: A review. N. Z. J. Bot. 29:311-316.