FURTHER GERMINATION EXPERIMENTS ON THE SEEDS OF NATIVE PLANTS

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INTRODUCTION AND METHODS

In the C.B.S.J. No 27 (Burrows, 1993) I outlined results of experiments carried out in 1989-90-91 on the germination behaviour of seeds of some New Zealand lowland woody plants. Since then several papers have emerged, elaborating on those bare details (Burrows, 1994 a, b; 1995a, b, c) and more are in the press. In the last two years I have done further, similar experiments on a range of different New Zealand species, as well as repeating tests on some species which were examined earlier. The same general methodology has been used, with some modifications.

As before, fruit are collected fresh from wild parent plants (from localities in Canterbury and Westland). Usually the collections are done as soon as the fruit are ripe. In species where fruit containing seeds remain for long periods on the parents. They may be collected later in the fruiting season, also.

The seeds are removed from their enclosing tissues and soaked in tapwater for 24 hours. My experiments have shown that seeds left in fleshy tissues (or in some dry fruit) germinate poorly, it at all. I have tried to speed up germination of seeds with thick, tough endocarp, or thick, hard seed coats by nicking then with a nail file. Only in the case of the hard-coated seeds (such as kowhai, *Sophora microphylla*) is this pre-treatment successful. Some difficult-to-germinate seeds are dormant (in the sense of Burrows, 1994a) and may need chilling treatments to facilitate germination. Other workers (e.g. Haase (1987) with *Hoheria glabrata*; Keogh & Bannister (1992) with *Discaria toumatou*) have obtained good results in this way. However, so far, I simply place my seeds in conditions suitable for germination, exposed to ordinary seasonal weather changes, and wait. Sometimes it takes several years, before all in a set of seeds germinate!

My standard treatment resembles the natural situation where cleaned seeds reach the ground and lie there, moist and in reasonably well-lit conditions, until they germinate. As for all other treatments, except those on soil, the experiments are maintained in petri dishes, with one sheet of filter paper, kept thoroughly moist and well-lit (i.e. with full access to the available light in the partially-shaded glasshouse where the experiments are carried out). In all the experiments modular numbers of 25 seeds per dish are used. In the standard treatment there are four replicates. As noted earlier, some seeds respond well if their coats are nicked with a nail file. Small sets of these are placed in conditions otherwise similar to the standard, from time to time.

In fruit treatment (2 replicates) seeds are left in the dry or fleshy pericarp tissues and otherwise treated as for the standard. Soil treatments (2 replicates) are placed in shallow grooves on soil in small plastic meat dishes, with drainage holes. They are kept moist by gentle watering. The soil has been put through steam treatment beforehand, to kill residual seeds, moss, liverwort and fern spores. In the past I carried out tetrazolium tests for potential seed viability (cf. Burrows, 1995a). However, this test proved to be rather unreliable so I have not used it in the recent work.

One new treatment is: dry (1 or 2 replicates), where seeds, after the pretreatment, are kept, dry, in petri dishes, for 4-6 months, then placed in conditions as for the standard. A further new treatment is buried where 1 set of seeds is kept in a 30 cm upright plastic cylinder, 10.4 cm in diameter, which is filled with soil, is open at the top and has drainage holes in the basal plate. It is kept moist by gentle watering. Relatively small seeds are buried, at 5 cm depth, in a plastic container with a stainless steel wire mesh bottom. Large seeds are buried at 10 cm in a nylon mesh bag.

Treatments other than standard simulate a range of conditions in which seeds may find themselves after dispersal. The dark and buried treatments examine features of the same phenomenon in different ways. The plastic envelope excludes light but otherwise the seeds are well aerated. Burial excludes light, but also subjects the seeds to enhanced amounts of carbon dioxide, as a result of microbial respiration. The soil treatment is probably closer to natural conditions than is the standard, but it is very difficult to see seeds in it clearly at all times, especially if they are small.

Although summer conditions in our forests may allow seeds to dry out for a time, as most seeds mature in autumn or winter, prolonged drying may seldom be encountered by seeds except those which are deeply dormant or have thick seed coats, and, thus, are present over the summer. However, it seems useful to test the longevity of seeds kept dry.

Nurserymen and others often "stratify" seeds, i.e. place them in appropriate containers, moist, in a refrigerator (at about 4°C) for a few months. This is a practice carried over from the Northern Hemisphere temperate zone experience, where many species of seeds are deeply dormant, to avoid germinating in harsh winter conditions. Paradoxically, the winter cold treatment is needed to cause chemical changes which bring the seeds out of dormancy when conditions improve in spring. Dormancy, thus, can be overcome by artificial chilling. As I have indicated (Burrows, 1994b) many of our seeds germinate in autumn or winter - so they do not necessarily need chilling. Indeed, some of them will germinate in the refrigerator. However, "stratification" may prolong the "shelf-life" of some seeds and may make it easier to germinate refractory, slow-to-germinate seeds, such as those of *Myrsine* spp., *Elaeocarpus* spp., *Melicope*. It is known to be effective for *Discaria* and *Hoheria glabrata*, but careful experiments need to be done on the other species, to establish their response to chilling.

My experiments are carried out in an unheated, partially-shaded small glasshouse at the garden area of the Plant and Microbial Sciences Department, University of Canterbury and monitored frequently (weekly for all treatments except dark, which is examined at about monthly intervals).

RESULTS

The summaries of results in Table 1, and in the text later, are for 19 species for which data are complete or almost complete; and for 11 species for which only limited data are available. Referring, firstly, to Table 1, it is clear that the percentage germination success was high for most species in the standard treatment. It was as high for a few species in one or more of dark, soil and dry treatments. More usually the germination success in these last three treatments was markedly lower than in the standard, and, for some species it was nil in the dark and dry treatments. Few seeds of any species germinated in the in-fruit treatment but eight (of 14 species tested) germinated, with the seedlings reaching the soil surface, in the buried experiment. Other buried seeds germinated but the seedlings failed to reach the soil surface. A few failed to germinate, but remained alive and germinated when brought to the surface.

Table 1 Germination Data for Seeds of Native Plant Species

	GERMINATION PATTERN**	PERCENTAGE GERMINATION SUCCESS IN TREATMENTS STANDARD	DARK	IN FRUIT	SOIL	BURIED	DRY
TREES							
*Alectryon excelsus**	3+	56	20	ND	58	24	60
Ascarina lucida	3	70	98	48	74	0	ND
Corynocarpus laevigata	2a	94	75	0	98	32	10
*Cordyline australis**	3, 4+	98	100	0	ND	24	72
Hoheria angustifolia	2a	93	88	as for standard	84	0	20
Melicytus lanceolatus	2a	100	72	20	80	0	68
Myrsine australis	5a	100	34	16	54	52	100
*Rhopalostylis sapida**	2c	100	84	ND	ND	48	ND
VINES							
Clematis paniculata	5a	92	0	as for standard	48	ND	0
Freycinetia baueriana	2a	92	0	0	12	0	0
*Ripogonum scandens**	2a+	100	96	ND	ND	64	0
SHRUBS							
Coprosma foetidissima	2a	98	4	4	94	ND	6
C. grandifolia	2a	100	32	16	100	ND	8
*C. lucida**	2b+	100	94	ND	ND	80	26
*C. robusta**	2a	100	94	ND	ND	36	72
Kunzea ericoides	2a	100	86	ND	76	0	92
Solanum laciniatum	2a	98	70	12	56	0	96
HERBS							
Astelia fragrans	3	98	92	0	86	ND	0
Dianella intermedia	2b	50	36	0	16	ND	ND

* Repeats of experiments reported in Burrows (1993). ND not done

** Germination patterns are: 1. all germinate within 6 weeks; 2. all germinate over a short period (a) within 2-5 months (b) within 6-9 months (c) within 10-12 months; 3. all germinate, gradually, within 6-12 months; 4. most seeds germinate as for 2a or b, but a small proportion remains dormant - they germinate after 10-12 months; 5. a few seeds germinate, sporadically, in the first 10 months, but the rest germinate (a) over a short period, or (b) gradually, in a second and/or a subsequent year.

\+ These patterns differ in some respects from those recorded in Burrows (1993); they reflect different behaviour of the respective seed sets.

Repeats of experiments with seeds of titoki, *Alectryon excelsus* and nikau, *Rhopalostylis sapida*, which did not germinate previously in the dark treatment (cf. Burrows, 1993), showed that appreciable numbers will, in fact, germinate in the dark (Table 1). Seeds of *Alectryon* in the standard treatment again had relatively low germination success. Two possible causes of this may be: (a) undetected damage to some seeds by larvae of a moth *Conopomorpha cyanospila* (cf. Sullivan et al., 1995); (b) damage to some seeds by fungi and algae which proliferate around seeds kept in petri dishes. During the pre-treatment it is very hard to remove the last vestiges of the fleshy aril which partly surrounds the seed. It is this aril tissue which encourages, first, fungal growth, then algae. In the previous dark treatments (Burrows, 1993) with both *Alectron* and *Rhopalostylis* the seeds were overcome by fungi. They were much less obviously affected in the present experiments.

Seeds of hutu, *Ascarina lucida*, that did not germinate in the standard treatment were adversely affected by algae. No evident cause could be seen for relatively low germination success of *Dianella intermedia* seeds in this treatment.

Soil treatment seeds, with a few exceptions, germinated less successfully and more slowly than those in the standard treatment. I have found that, by pricking out standard treatment seedlings onto potting mix soil when they are still very small, there is a high survival rate. This practice is, therefore, recommended, especially for species where germination on soil is often poor. Bear in mind, however, that I carefully inspect the seeds I am placing in my experiments to ensure that none are empty, damaged or diseased. The whole procedure is tedious, but it is certainly worthwhile for getting unambiguous experimental results (with exceptions, as for *Alectryon*).

Of the species with seeds which germinated when buried in the soil, karaka, *Corynocarpus laevigata*, *Alectryon*, *Rhopalostylis* and supplejack, *Ripogonum scandens* have relatively large seeds, but *Coprosma lucida*, *C. robusta*, *Cordyline australis* and *Myrsine australis* have relatively much smaller seeds. The capacity for extension of the hypocotyl of the new seedling, so that the cotyledons or plumule emerge above the soil surface, is more significant than mere gross size of the seed. In nature these seeds will be able to germinate if shallowly buried. A great deal of further experimentation is needed to determine how deeper burial affects the seeds; some may become dormant if deeply buried.

The following notes outline germination results for species for which only limited information is available. Most of the experiments were carried out in the standard conditions, as for those in Table 1. Germination patterns are indicated (in parentheses) for each species, as in Table 1; one additional symbol is N - seeds germinate relatively rapidly if their coats are nicked.

Calystegia tuguriorum (5n, N). The seeds have very hard, thick coats, like those of kowhai (*Sophora* spp.). In an experiment started in 1989 there was very slow, sporadic germination over 5 years; at the end of that period only 18% of the seeds had germinated. When the seeds are ready to sprout (after the coat has partially decayed and water enters) they swell to about twice their original size. A fresh set of seeds, when nicked with a nail file, all swelled and germinated within two weeks.

Cordyline banksii (3). Seeds obtained from a plant of unknown origin, grown in a garden at the University of Canterbury, germinated with 95% success, over the autumn and winter.

C. indivisa (2a). Seeds from a plant in our garden in Avonhead, which originated as a seedling at Sewell Peak, southern Paparoa Range, Westland, germinated, with 89% success over the winter.

Dacrycarpus dacrydioides (2c/5b?). I have not managed to obtain seeds from this species for glasshouse experiments. However, while doing experiments on the development of soil banks I put trays of sterile soil in Ahuriri Summit Bush on the Port Hills in January 1990. I left them out for six months, then brought them into a glasshouse at the University of Canterbury to monitor seed germination. In 1990-91 substantial numbers of *D. dacrydioides* seeds germinated 6-9 months after the trays were placed in the glasshouse. No more germinated subsequently.

Dodonaea viscosa (3, N). The seed coats are very hard and germination normally is slow (as parts of the coat gradually decay and admit water). After a fresh set of seeds was nicked with a nail file they swelled to about twice their former size and germinated in just over a month. However, when a second set was nicked, they germinated sporadically over about two and a half months (but, nevertheless, at a faster rate than in seeds where the coat was left intact).

Griselinia lucida (1). The seeds have very thin coats; they die if they dry out. Placed in standard conditions, a set of seeds germinated within two weeks (100% success).

Ileostylus micranthus (1). The embryos appear to have minimal covering. Only 20% of a set of seeds germinated; the rest died and were soon mouldy. When kept wet, in petri dishes, the small seedlings died within three months.

Metrosideros perforata (1). The tiny seeds of this species were soaked for 24 hours prior to putting them into the experimental conditions. In that time a few had already begun to germinate, so all of the seed set (several hundred individuals) were broadcast on damp soil in a pot. The numbers germinating were not counted, but a very large proportion of the seeds had germinated within a week.

Myrsine salicina (3). A set of the seeds germinated with 98% success.

Podocarpus hallii (2c/5b?). Under conditions the same as for *Dacrycarpus* (above) seeds of this species germinated 3-15 months after soil trays were brought from the forest back to my glasshouse. No more germinated subsequently.

Tupeia antarctica (1). Seeds of this species are very thin-walled, like those of *Ileostylus* (above). They germinated at about the same rate, but with 92% success. Also, the seedlings persisted in petri dishes for more than 12 months.

CONCLUSIONS

The results reinforce the view outlined by Burrows (1994a) that seeds of many New Zealand forest species can germinate either soon after dispersal in late summer - autumn or during the winter. Seeds of some species, however, are constrained by low temperatures and require warm spring or summer conditions before they will germinate.

A considerable number of species (cf. Burrows, 1993, as well as the present results) have, among individuals within a seed cohort, (a set derived from one years' seeding) varied responses to climate conditions. This has the effect of spreading germination of seeds from the whole population over a long period; at least some seedlings should strike good conditions for subsequent growth.

One deduction from the results of these tests is that there is not much evidence (except in the case of the hard-coated seeds) for seed species which could last for periods longer than a few months in soil seed banks. Not many hard-coated, water-impenetrable seed species have been tested so far. Most of our native legumes are likely to be in this category. Some testing of the effects of deep burial is needed to investigate another possible influence on seed bank development. When seeds of plants growing in harsher environments than the lowland forests are tested, however, more species may be found that have truly dormant seeds (in the sense of Burrows, 1994a) which can persist in the soil for long periods. This is true for Discaria (Keogh & Bannister, 1992), which also has hard-coated seeds. In the lowland forests for most species seed banks, either maintained on the parent plants, or in the litter, appear to be of short duration (usually less than a year).

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