# SEED STORAGE OF SEVERAL NEW ZEALAND INDIGENOUS TREES

## PART I — KAURI (*AGATHIS AUSTRALIS*)

DAVID PREEST

Forest Research Institute, New Zealand Forest Service, Rotorua

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ABSTRACT

The viability of kauri seed is ephemeral under ambient conditions. Since collection is difficult, hazardous, and therefore expensive, a satisfactory method of storing seed surplus to requirements would be valuable.

Kauri seed was stored in air-tight containers for up to 11.7 years at moisture contents of 6%, 10%, 15%, and 20% oven-dry weight and at constant temperatures of —10°, 5°, 10°, 15° and 20°C. Seed longevity was heavily dependent on both these factors, though moisture content was the more critical. The optimum moisture content appeared to be around 6%. For short- to medium-term storage (up to 6 years) the optimum temperature was about 5°C. For longer storage or higher moisture content (10%) the results suggested that the optimum temperature was below freezing point.

This experiment showed that kauri seed can be kept for 5-6 years with viability little impaired, and probably in excess of 12 years with fair viability retained, if stored air-tight under conditions of low moisture content and temperature.

## INTRODUCTION

Kauri (*Agathis australis* Hort. ex Lindl.) has an abiding fascination for New Zealanders. Persistent attempts spanning 40-50 years have been made to propagate the species artificially by raising seedlings in nurseries and planting them out. Nursery propagation from seed has always proved feasible: to a large extent this has been due to abundant, and regular seed crops, the ease with which the fresh seed germinates, and a reasonably fast rate of juvenile growth. But seed collection is difficult, hazardous, and therefore expensive. It is desirable therefore that seed surplus to requirements one year be able to be stored for sowing in subsequent years.

Despite Hutchin's (1918) statement that "there is evidence that kauri seed will lie dormant in the ground for many years . . .", it is well known that kauri seed loses viability quickly under ambient conditions of temperature and relative humidity. Hocking (1935) found that "Stored kauri seed had lost all viability 18 months after collection". McKinnon (1936) noted a 60% drop in the viability of seed stored in a sealed glass jar after 6 months. Sando (1936) states that "The viability of stored seed is evanescent. In a few weeks it has diminished considerably. . . ."

MacMorran's (1946) work indicated that temperature was an important factor. She found that kauri seed stored at room temperature for 2 years had lost all viability, whereas that stored at —9.4° to —12.2°C still retained 64% of its original viability. Mirams (1957) showed that seed stored under conditions of 10% relative humidity (approximately 9% seed moisture content (m.c.)) had a germination of 55% after 12.6 months, compared with approximately 13% after 1.6 months and 0% after 5.3 months for seed stored at 100% relative humidity (seed m.c. approx. 20%). Unfortunately, MacMorran did not specify the seed moisture content and Mirams did not specify the storage temperature.

The successful long-term storage of many seeds depends critically upon seed moisture content, storage temperature, and the gaseous environment, especially the exclusion of oxygen (Roberts, 1972). The purpose of this experiment was to determine the influence of seed moisture content and storage temperature on kauri seed longevity under air-tight (anaerobic) storage conditions.

## METHODS

The effect on seed viability of storage at four different moisture contents and five different temperatures was investigated over a period of 11.7 years.

Seed for the experiment was collected at Waipoua State Forest during the first 2 weeks of March 1957 (N.Z. Forest Service Seedlot No. AK 57/731). It was extracted cleaned, and air-dried there also. It was received at the Forest Research Institute, Rotorua, in mid-May. After further cleaning and dewinging, and winnowing to remove the empty seeds and wings, 4.54 kg of seed yielded 2.5 kg of pure seed, which was found by cutting test to be 96% sound. The initial high germination of 88% (*see* Table 1) indicated that these procedures were not detrimental to seed quality.

Further drying of seed under forced draught at 30-35°C for 24 hours was then carried out. At this point the bulk seed was split into four lots using an ore sample splitter. Each lot was passed several more times through the splitter to yield a single sample of approximately 20 g. These four samples (one from each lot) were then combined giving a composite sample of approximately 86 g.

The four lots were sealed up separately to prevent further moisture content changes. The composite sample was oven-dried at 100-104°C for 50 hours*, and was found to have a moisture content of 6.1% of the oven-dry (o.d.) weight.

One of the four lots was then dried to a weight equivalent to 6% m.c., while calculated amounts of water were sprayed on to the other three to bring their moisture contents up to 10, 15, and 20% of o.d. weight. Each of these three lots was thoroughly mixed and regularly shaken up in a sealed plastic bag over a 24-hour period to ensure even distribution of the moisture among the seed.

All four lots were then weighed into germination test samples of approximately 580 sound seeds each. These were immediately sealed into individual 0.0076-mm thick,

* The International Seed Testing Association rules (1966) for determining seed moisture contents were not promulgated at the commencement of this experiment. It is possible that the toluene distillation method recommended for several coniferous tree species would have been more appropriate. The absolute moisture contents may therefore have been somewhat lower than those indicated by the method actually used.

TABLE 1—Germination of kauri seed stored air-tight for up to 140 months (11.7 years) at various moisture contents and temperatures. Each germination percentage is the mean of four 100-seed test samples

| Moisture content (% o.d. weight) | Storage temperature (°C) | Months of Storage: 0 | 14 | 26 | 36 | 48 | 73 | 100 | 140 |
|---|---|---|---|---|---|---|---|---|---|
| | | Germination (%) | | | | | | | |
| 6 | — 10 | 88.0 | 66.8 | 60.8 | 61.5 | 63.3 | 65.5 | 57.0 | 57.3 |
| | 5 | 88.0 | 83.5 | 77.5 | 78.3 | 84.3 | 79.3 | 54.0 | 38.5 |
| | 10 | 88.0 | 86.5 | 77.3 | 79.3 | 85.3 | 69.0 | 31.0 | 7.3 |
| | 15 | 88.0 | 83.2 | 73.3 | 74.0 | 57.8 | 21.3 | 0.7 | 0.5 |
| | 20 | 88.0 | 86.0 | 70.8 | 56.3 | 43.0 | 4.5 | 0 | 0 |
| 10 | — 10 | 88.0 | 77.0 | 72.8 | 62.3 | 72.5 | 63.5 | 69.0 | 62.5 |
| | 5 | 88.0 | 74.0 | 56.0 | 31.8 | 12.8 | 1.3 | 0 | 0 |
| | 10 | 88.0 | 53.5 | 8.0 | 1.3 | 0 | 0 | — | — |
| | 15 | 88.0 | 1.3 | 0 | 0 | — | — | — | — |
| | 20 | 88.0 | 0 | 0 | — | — | — | — | — |
| 15 | — 10 | 88.0 | 0.8 | 0.5 | 0.3 | 0.3 | 0 | 0 | — |
| | 5 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 10 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 15 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 20 | 88.0 | 0 | 0 | — | — | — | — | — |
| 20 | — 10 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 5 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 10 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 15 | 88.0 | 0 | 0 | — | — | — | — | — |
| | 20 | 88.0 | 0 | 0 | — | — | — | — | — |

Note: Dashes indicate no tests carried out and follow two consecutive zero test results.

polyethylene, double-walled, plastic bags. Each set of germination test samples of the same moisture content was divided into five sub-sets sealed in screw-cap, glass, preserving jars. Thus, each set of samples of a given moisture content for storage at a given temperature was sealed in its own jar.

The five storage temperatures were —10°, 5°, 10°, 15°C, and room temperature (a temperature-controlled basement maintained fairly constantly near 20°C). Storage at —10°C was in a deep freeze at the Forest Research Institute, Rotorua. Temperature-controlled facilities at the Seed Testing Station of the Ministry of Agriculture and Fisheries, Palmerston North. were used for storage at the other temperatures. The seed was placed in storage 12 weeks after collection.

Germination tests were carried out at 0, 26, 36, 48. 73, 100, and 140 months (11.7 years). For the 0-, 26-, and 36-month tests a sample packet was withdrawn from each of the 20 jars representing the 20 different storage conditions. Immediately upon withdrawal of a sample packet the jar was re-sealed with a new seal. After zero germination results in two successive tests no further testing of samples from those particular storage conditions was undertaken.

From each sample packet, 4 × 100 seed sub-samples of "plump" seed were taken for germination testing. Within 24 hours of removal from storage they were placed on wick-fed, cellulose, test pads ("germination blotters") at a temperature of 24°C, at the Seed Testing Station. The tests were carried on until no further germination appeared likely, usually about 35 days.

## RESULTS AND DISCUSSION

The results are shown in terms of mean germination percentages in Table 1 and graphed as response surfaces in Figs. 1 and 2. Some fluctuation in germination percentage is exhibited with time instead of the monotonic decreases which might be expected. These fluctuations are possibly due to some variation from year to year in the sampling technique used, and possibly to differences in seed treatment or germination conditions at the Seed Testing Station. No logical explanation relating to seed behaviour can be suggested.

It is apparent that the viability of kauri seed can be retained for long periods of time when it is stored under air-tight conditions at suitable seed moisture contents and temperatures. The results indicate that moisture content is the more critical factor as there was virtually a complete loss of viability within 14 months at all temperatures of all seed with 15% and 20% m.c. (Fig. 2, A-E). Even the seed with 10% m.c. retained good viability only at the lowest storage temperature (—10°C) (Figs. 1B, 2A).

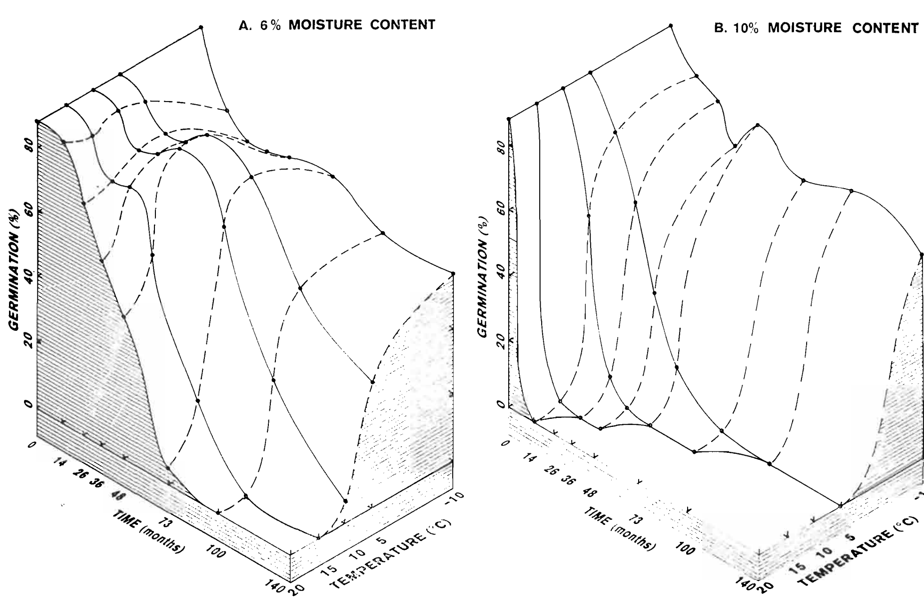
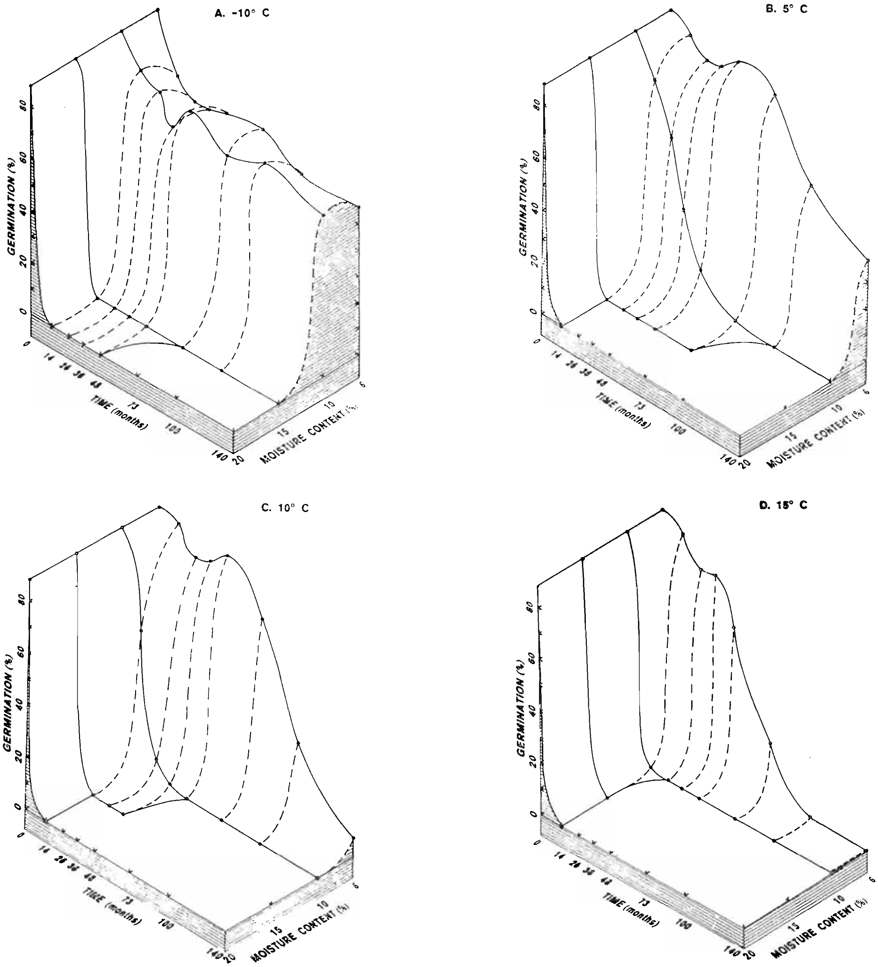



FIG. 1—Response surfaces of kauri seed germination percentage, with storage temperature and time at two different seed storage moisture contents. (Data points are circled.)



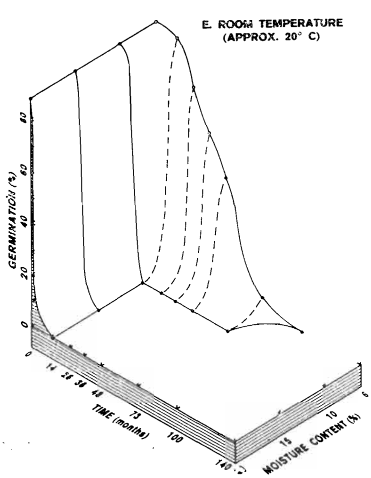




FIG. 2—Response surfaces of kauri seed germination percentage, with storage moisture content and time at five different seed storage temperatures. (Data points are circled.)

With 6% seed m.c., good (85.3%) to fair (43%) viability was preserved for up to 48 months at all temperatures, including room temperature (20°C), but only the seed stored at — 10°C retained good viability for the duration of the experiment (Figs. 1A, 2A).

The 10% m.c. results indicate that at this moisture content the seed is best stored below freezing point. However, at 6% m.c. the picture is less clear. There are indications (Fig. 1A) that for storage up to 73 months (approximately 6 years) temperatures just above freezing are best, whereas for longer term viability sub-zero storage results in greatest longevity. It is difficult to explain this apparent anomaly — unless one assumes that a certain percentage of the seed (seed which is possibly less mature (Austin, 1972) or of different genotype (Roberts, 1972)) is adversely affected by freezing while the remainder is not, so that eventually the viability of the seed stored at — 10°C as a whole exceeds that of the seed stored at 5°C. Since it is very unlikely that kauri seed would need to be stored for more than 4 years, it would appear that for practical purposes storage at 5°C would be adequate and may, in fact, be near optimal.

While at 5°C (Fig. 2B) the optimum moisture content is nearer to 6% than 10%, no clear-cut indication of the optimum for storage at — 10°C is apparent from Fig. 2A. In view of the generally higher level of viability maintained at all times and temperatures (except — 10°C) at 6% m.c. (Fig. 1A) than at 10% m.c. (Fig. 1B), it could be inferred that the optimum is nearer to 6% than 10%. However, as already suggested, the optimum could vary with storage temperature and time.

## CONCLUSIONS

Accepting that these results are based on one experiment with one seedlot of one provenance, it is tentatively concluded that:

(1) The seed of kauri can be stored under air-tight conditions with little impairment of viability for 5-6 years, but seed moisture content and storage temperature are critical;

(2) The more important factor is moisture content, the optimum apparently being around 6% of o.d. weight;

(3) The optimum temperature for short- to medium-term storage (up to 6 years) is 5°C although, provided the moisture content is low enough (6%), the seed will keep well for 2 years even at room temperature (approx. 20°C);

(4) For long-term storage (exceeding 6 years) the optimum storage temperature may be below freezing point.

As kauri seed can suffer rapid serious loss of viability if both moisture content and temperature are high, it is important that it be placed in air-tight storage under the conditions indicated by this work as soon as practicable after collection.

## ACKNOWLEDGMENTS

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## REFERENCES

AUSTIN, R. B. 1972: Effects of environment before harvesting on viability. Pp. 114-49 **in** Roberts, E. H. (ed.): "Viability of Seeds". Chapman and Hall Ltd, London.

HOCKING, G. H. 1935: A note on the germination of some native species. **New Zealand Journal of Forestry 3:** 225-7.

HUTCHINS, D. E. 1918: "Waipoua Kauri Forest, Its Demarcation and Management". Department of Lands and Survey, Wellington.

McKINNON, A. D. 1936: Collection and germination of kauri (**Agathis australis**) seed. **New Zealand Journal of Forestry 4:** 129.

MacMORRAN, A. M. 1946: Experimental seed storage. **Journal of the Royal New Zealand Institute of Horticulture 15:** 24-5.

MIRAMS, R. V. 1957: Aspects of the natural regeneration of the kauri (**Agathis australis** Salisb.). **Transactions of the Royal Society of New Zealand 34(4):** 661-80.

ROBERTS, E. H. 1972: Storage environment and the control of viability. Pp. 14-58 **in** Roberts, E. H. (ed.): "Viability of Seeds". Chapman and Hall Ltd, London.

SANDO, C. T. 1936: Notes on **Agathis australis. New Zealand Journal of Forestry 4:** 16-21.