

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**SEED DORMANCY AND
GERMINATION OF A PANEL OF
NEW ZEALAND PLANT SPECIES:**

*Carex trifida, Coprosma robusta, Cyperus ustulatus, Hebe
stricta, Muehlenbeckia australis, Myrsine australis,
Phormium tenax and Sophora prostrata*

*A thesis presented in partial fulfilment of the requirements for the
Degree of Master of Science at Massey University,*

Palmerston North,

New Zealand.

ALLISON MACKAY

2004

Abstract

Literature was reviewed on the germination and possible uses for revegetation of the New Zealand indigenous species selected. Seeds of *Carex trifida*, *Coprosma robusta*, *Cyperus ustulatus*, *Hebe stricta*, *Leptospermum scoparium*, *Muehlenbeckia australis*, *Myrsine australis*, *Phormium tenax*, *Phormium* 'Yellow Wave' and *Sophora prostrata* were assessed for germination rates, percentage germination, dormancy and the effects that temperature has on germination. Seeds of *Carex*, *Cyperus* and *Myrsine* showed no germination in light or dark at 20°C. In contrast, 12 weeks of low temperature stratification resulted in a high percentage of seed germinating for *Carex* and *Cyperus*. There was no germination of *Myrsine* despite high viability in the initial germination experiment and the stratification experiment. Removal of the endocarp and a period of stratification increased germination percentage of *Myrsine* to 91%. Germination was low for *Muehlenbeckia* in the light at 20°C, but 4 weeks of low temperature stratification increased germination rate. After 2 years, 80% of *Coprosma* seeds germinated but germination rate increased after subjecting the seed to 8 weeks or more of stratification. No seeds of *Coprosma* or *Muehlenbeckia* germinated in the dark. Rapid germination of *Hebe* seeds was obtained, with 100% of the seed germinating in the light while only 7% germinated in the dark. *Leptospermum* had rapid germination, with 100% germinating in the light, while only 3% germinated in the dark. A low percentage of *Phormium* seed germinated in both the light and dark in the first month and no further germination was observed. In contrast, 8 weeks or more of low temperature stratification resulted in almost complete germination. There was rapid germination of *Sophora* seeds with 100% of the seed germinating in the light and dark. *Carex* seed had a limited temperature range at which it germinated (22°C to 26°C), while *Cyperus* had a wider range (18°C to 32°C) but did not germinate at low temperatures (6°C to 14°C). The optimum germination range for *Cyperus* was 24°C to 30°C. *Hebe* did not germinate at high temperatures (30°C to 32°C) but successfully germinated at all other temperatures with the optimum germination range being 6°C to 24°C. *Leptospermum* did not germinate at 6°C but had maximum germination at most other temperatures. *Muehlenbeckia* and *Phormium* germinated at all temperatures tested (6°C to 32°C) with the most seed germinating at 20°C for *Muehlenbeckia* and between 14°C to 22°C for *Phormium*. *Sophora* did not germinate at the low temperatures (6°C to 10°C). The germination rate increased with temperature for *Cyperus*, *Hebe*, *Leptospermum*, *Muehlenbeckia*, and *Phormium*. Generally, for *Carex* and *Sophora* as temperature increased germination rate slowed. It appeared that light is required for *Hebe* and *Leptospermum* to germinate. *Sophora* required scarification but not light. *Coprosma* and *Muehlenbeckia* required light and a period of chilling to increase the rate of germination. A small

percentage of the *Phormium* population is not dormant but a period of chilling increased the germination percentage for that portion of the population that is dormant. *Carex* and *Cyperus* required a period of chilling in order to break dormancy. *Myrsine* required removal of endocarp and a period of chilling to germinate. A list of cleaning descriptions and the equipment that was used for each species studied is reported. Preliminary results of a hydroseeding trail using the species studied were also reported.

Acknowledgements

I would like to express my sincere gratitude and appreciation to the following people and organisations:

Firstly, thank you to Associate Professor David Fountain, my chief supervisor, for his guidance, supervision and help throughout the duration of the research and editing of this thesis. Thankyou also to Dr John Clemens my second supervisor, for advice given throughout the research, his help with the hydroseeding trial, and detailed editing of this thesis.

I would like to acknowledge help and assistance from those at the Centre for Plant Reproduction and Seed Technology, especially Craig McGill and Robert Southward. Thanks also goes to Ruth Morrison for seed testing of the grasses used in the hydroseeding trial.

Thank you to Raymond Bennett and Doug Hopcroft of HortResearch Institute for their assistance with the histology and light microscopy.

I am very grateful to The Foundation for Research, Science & Technology for funding the research. Thank you also, to Robert Coulsen of Rural Supply Technologies Ltd. for his involvement and ideas with regards to this research.

Finally, a special thanks to my daughters, Melissa, Jessica and Louise, who spent hours helping to collect seeds and to my husband Craig for his support and encouragement as well as his help with the computer technology.

Table of Contents

| | |
|---|-------------|
| Abstract | ii |
| Acknowledgements | iv |
| List of Tables | ix |
| List of Figures | ix |
| List of Plates | xi |
| List of Appendices | xiii |
| 1 INTRODUCTION | 1 |
| 2 LITERATURE REVIEW | 4 |
| 2.1 Overview of Dormancy | 4 |
| 2.1.1 Background | 4 |
| 2.1.2 Dormancy and Quiescence | 10 |
| 2.1.3 Primary (Innate) and Secondary (Induced) Dormancy | 11 |
| 2.1.4 Embryo Dormancy | 12 |
| 2.1.5 Coat-imposed Dormancy | 13 |
| 2.2 Selected Species and their Seeds | 17 |
| 2.2.1 <i>Carex trifida</i> | 17 |
| 2.2.1.1 Species Description | 17 |
| 2.2.1.2 Seed Storage | 19 |
| 2.2.1.3 Seed Germination | 19 |
| 2.2.2 <i>Coprosma robusta</i> | 20 |
| 2.2.2.1 Species description | 20 |
| 2.2.2.2 Seed Storage | 23 |
| 2.2.2.3 Seed Germination | 24 |
| 2.2.2.4 Seed Germination Experiments | 24 |
| 2.2.2.5 Other Seed Germination Experiments | 24 |
| 2.2.3 <i>Cyperus ustulatus</i> | 26 |
| 2.2.3.1 Species Description | 26 |
| 2.2.3.2 Seed Germination Experiments | 27 |
| 2.2.3.3 Seed Storage | 28 |
| 2.2.4 <i>Hebe stricta</i> | 29 |

| | | |
|----------|---------------------------------|-----------|
| 2.2.4.1 | Species Description | 29 |
| 2.2.4.2 | Seed Storage | 32 |
| 2.2.4.3 | Seed Germination | 33 |
| 2.2.4.4 | Seed Germination Experiments | 33 |
| 2.2.5 | <i>Leptospermum scoparium</i> | 34 |
| 2.2.5.1 | Species Description | 34 |
| 2.2.5.2 | Seed Storage | 38 |
| 2.2.5.3 | Seed Germination | 39 |
| 2.2.5.4 | Seed Germination Experiments | 39 |
| 2.2.6 | <i>Muehlenbeckia australis</i> | 43 |
| 2.2.6.1 | Species Description | 43 |
| 2.2.6.2 | Seed storage | 45 |
| 2.2.6.3 | Seed germination | 45 |
| 2.2.6.4 | Seed germination experiments | 45 |
| 2.2.6.5 | Other germination experiments | 45 |
| 2.2.7 | <i>Myrsine australis</i> | 46 |
| 2.2.7.1 | Species Description | 46 |
| 2.2.7.2 | Seed Storage | 49 |
| 2.2.7.3 | Seed Germination | 49 |
| 2.2.7.4 | Seed Germination Experiments | 49 |
| 2.2.7.5 | Other Germination Experiments | 50 |
| 2.2.8 | <i>Phormium tenax</i> | 51 |
| 2.2.8.1 | Species Description | 51 |
| 2.2.8.2 | Seed Storage | 57 |
| 2.2.8.3 | Seed Germination | 58 |
| 2.2.9 | <i>Sophora prostrata</i> | 59 |
| 2.2.9.1 | Species Description | 59 |
| 2.2.9.2 | Seed Storage | 62 |
| 2.2.9.3 | Seed Germination | 62 |
| 2.2.9.4 | Seed Germination Experiments | 63 |
| 3 | MATERIALS AND METHODS | 64 |
| 3.1 | Seed Collection | 64 |
| 3.2 | Seed Storage | 64 |
| 3.3 | General Experimental Procedures | 64 |

| | | |
|----------|---|-----------|
| 3.3.1 | Seed moisture content (SMC) | 65 |
| 3.3.2 | Seed Viability | 66 |
| 3.3.3 | Seed Germination Experiments | 66 |
| 3.3.4 | Seed Stratification Experiments | 67 |
| 3.4 | The Effect of Seed Storage | 68 |
| 3.5 | The Effect of Temperature on Germination | 69 |
| 3.6 | Fixation and Evaluation of Seed Material for Light Microscopy | 71 |
| 4 | RESULTS | 73 |
| 4.1 | Fruit and Seed Description | 73 |
| 4.1.1 | <i>Carex trifida</i> | 73 |
| 4.1.2 | <i>Coprosma robusta</i> | 75 |
| 4.1.3 | <i>Cyperus ustulatus</i> | 77 |
| 4.1.4 | <i>Hebe stricta</i> | 78 |
| 4.1.5 | <i>Leptospermum scoparium</i> | 80 |
| 4.1.6 | <i>Muehlenbeckia australis</i> | 81 |
| 4.1.7 | <i>Myrsine australis</i> | 83 |
| 4.1.8 | <i>Phormium tenax</i> | 85 |
| 4.1.9 | <i>Sophora prostrata</i> | 86 |
| 4.2 | Seed Moisture and Viability | 87 |
| 4.2.1 | The Effect Of Seed Storage after 12 Months | 87 |
| 4.3 | Seed Germination | 88 |
| 4.3.1 | <i>Carex trifida</i> | 90 |
| 4.3.2 | <i>Coprosma robusta</i> | 90 |
| 4.3.3 | <i>Cyperus ustulatus</i> | 90 |
| 4.3.4 | <i>Hebe stricta</i> | 91 |
| 4.3.5 | <i>Leptospermum scoparium</i> | 91 |
| 4.3.6 | <i>Muehlenbeckia australis</i> | 92 |
| 4.3.7 | <i>Myrsine australis</i> | 92 |
| 4.3.8 | <i>Phormium tenax</i> | 93 |
| 4.3.9 | <i>Sophora prostrata</i> | 93 |
| 4.4 | The Effect of Temperature on Germination | 94 |
| 4.4.1 | <i>Carex trifida</i> | 94 |
| 4.4.2 | <i>Coprosma robusta</i> | 95 |
| 4.4.3 | <i>Cyperus ustulatus</i> | 95 |

| | | |
|----------|--------------------------------|------------|
| 4.4.4 | <i>Hebe stricta</i> | 97 |
| 4.4.5 | <i>Leptospermum scoparium</i> | 98 |
| 4.4.6 | <i>Muehlenbeckia australis</i> | 100 |
| 4.4.7 | <i>Phormium tenax</i> | 102 |
| 4.4.8 | <i>Sophora prostrata</i> | 104 |
| 5 | DISCUSSION | 106 |
| 5.1 | Seed Moisture and Seed Storage | 106 |
| 5.2 | Germination | 108 |
| 5.2.1 | <i>Carex trifida</i> | 108 |
| 5.2.2 | <i>Coprosma robusta</i> | 109 |
| 5.2.3 | <i>Cyperus ustulatus</i> | 111 |
| 5.2.4 | <i>Hebe stricta</i> | 112 |
| 5.2.5 | <i>Leptospermum scoparium</i> | 113 |
| 5.2.6 | <i>Muehlenbeckia australis</i> | 114 |
| 5.2.7 | <i>Myrsine australis</i> | 115 |
| 5.2.8 | <i>Phormium tenax</i> | 116 |
| 5.2.9 | <i>Sophora prostrata</i> | 117 |
| 5.3 | CONCLUSIONS | 120 |

List of Tables

| | | |
|------------------|---|-----|
| Table 3.1 | The nine species of plants, their collection site locations, the map grid reference (NZMS 260), and seed collection dates. | 65 |
| Table 3.2 | The number of seeds used for each seed moisture content and relevant details concerning extraction processes prior to the seed moisture content test. | 66 |
| Table 3.3 | The table prescribes procedures for preparation of pre-moistened seeds before staining. | 67 |
| Table 3.4 | Dates that seeds were placed on the Grant Temperature Gradient plate and the number of seeds used. | 70 |
| Table 4.1 | Seed moisture content at harvest and storage, and seed viability preceding the stratification experiment. | 87 |
| Table 4.2 | Seed viability after 12 months storage. | 88 |
| Table 4.3 | Seed germination data for light and dark (thiram and non-thiram) treatments. | 89 |
| Table 4.4 | Final percentage germination of seeds of <i>Carex trifida</i> , <i>Coprosma robusta</i> , <i>Cyperus ustulatus</i> , <i>Muehlenbeckia australis</i> , <i>Myrsine australis</i> , <i>Phormium tenax</i> , <i>Phormium</i> 'Yellow Wave' after stratification at 5°C for 0, 4, 8 or 12 weeks and subsequent incubation at 20°C. | 90 |
| Table 5.1 | Seed moisture content (SMC) at storage, seed viability preceding the stratification, seed viability after 12 months storage, requirements to break dormancy and time to 50% germination at 20°C and 26°C. | 120 |

List of Figures

| | | |
|-------------------|--|----|
| Figure 4.1 | The effect of light on the germination percentage of <i>Hebe stricta</i> seed. | 91 |
| Figure 4.2 | The effect of light on the germination percentage of <i>Leptospermum scoparium</i> seed. | 92 |
| Figure 4.3 | The effect of light on the germination percentage of <i>Sophora prostrata</i> seed. | 93 |
| Figure 4.4 | The effect of temperature on the germination percentage of <i>Carex trifida</i> seed. | 94 |
| Figure 4.5 | Temperature dependence of germination of <i>Carex trifida</i> . | 94 |

| | | |
|--------------------|---|-----|
| Figure 4.6 | The effect of temperature on germination rate of <i>Carex trifida</i> seed. | 95 |
| Figure 4.7 | The effect of temperature on the germination percentage of <i>Cyperus ustulatus</i> seed. | 96 |
| Figure 4.8 | Temperature dependence of germination of <i>Cyperus ustulatus</i> . | 96 |
| Figure 4.9 | The effect of temperature on germination rate of <i>Cyperus ustulatus</i> seed. | 96 |
| Figure 4.10 | The effect of temperature on the germination percentage of <i>Hebe stricta</i> seed. | 97 |
| Figure 4.11 | Temperature dependence of germination of <i>Hebe stricta</i> . | 98 |
| Figure 4.12 | The effect of temperature on germination rate of <i>Hebe stricta</i> seed. | 98 |
| Figure 4.13 | The effect of temperature on the germination percentage of <i>Leptospermum scoparium</i> seed. | 99 |
| Figure 4.14 | Temperature dependence of germination of <i>Leptospermum scoparium</i> . | 99 |
| Figure 4.15 | The effect of temperature on germination rate of <i>Leptospermum scoparium</i> seed. | 100 |
| Figure 4.16 | The effect of temperature on the germination percentage of <i>Muehlenbeckia australis</i> seed. | 101 |
| Figure 4.17 | Temperature dependence of germination of <i>Muehlenbeckia australis</i> . | 101 |
| Figure 4.18 | The effect of temperature on germination rate of <i>Muehlenbeckia australis</i> seed. | 102 |
| Figure 4.19 | The effect of temperature on the germination percentage of <i>Phormium tenax</i> seed. | 103 |
| Figure 4.20 | Temperature dependence of germination of <i>Phormium tenax</i> . | 103 |
| Figure 4.21 | The effect of temperature on germination rate of <i>Phormium tenax</i> seed. | 103 |
| Figure 4.22 | The effect of temperature on the germination percentage of <i>Sophora prostrata</i> seed. | 105 |
| Figure 4.23 | Temperature dependence of germination of <i>Sophora prostrata</i> seed. | 105 |

- Figure 4.24** The effect of temperature on germination rate of *Sophora prostrata* seed. 105

List of Plates

- | | | |
|------------------|--|----|
| Plate 2.1 | <i>Carex trifida</i> seed heads. | 17 |
| Plate 2.2 | <i>Coprosma robusta</i> planted as part of a revegetation project at Massey University. | 20 |
| Plate 2.3 | <i>Cyperus ustulatus</i> with seed heads. | 26 |
| Plate 2.4 | <i>Hebe stricta</i> planted as part of a revegetation project at Massey University (Turitea Campus). | 29 |
| Plate 2.5 | <i>Leptospermum scoparium</i> planted as part of a revegetation project at Mt Biggs, Sandon Road. | 34 |
| Plate 2.6 | <i>Muehlenbeckia australis</i> in flower. | 43 |
| Plate 2.7 | <i>Myrsine australis</i> newly planted at Massey University (Turitea Campus). | 46 |
| Plate 2.8 | <i>Phormium tenax</i> planted as part of a green corridor project at Makino Road, Feilding. | 51 |
| Plate 2.9 | <i>Sophora prostrata</i> bush growing on a hillside at Banks Peninsula. Inset: <i>S. prostrata</i> flower. | 59 |
| Plate 4.1 | <i>Carex trifida</i> seed heads. | 73 |
| Plate 4.2 | <i>Carex trifida</i> seeds that are trigonous in shape. | 73 |
| Plate 4.3 | <i>Carex trifida</i> seed cut in half longitudinally. | 74 |
| Plate 4.4 | Light microscopic oblique section of <i>Carex trifida</i> seed. | 74 |
| Plate 4.5 | <i>Coprosma robusta</i> mature and immature fruits. | 75 |
| Plate 4.6 | Seeds of <i>Coprosma robusta</i> . | 75 |

| | | |
|-------------------|--|----|
| Plate 4.7 | A <i>Coprosma robusta</i> seedling and germinating seed. | 75 |
| Plate 4.8 | A <i>Coprosma robusta</i> seed cut in half longitudinally. | 76 |
| Plate 4.9 | Light microscopic section of <i>Coprosma robusta</i> seed. | 76 |
| Plate 4.10 | Seeds of <i>Cyperus ustulatus</i> . | 77 |
| Plate 4.11 | A <i>Cyperus ustulatus</i> seed cut in half longitudinally. | 77 |
| Plate 4.12 | Seeds of <i>Hebe stricta</i> . | 78 |
| Plate 4.13 | An entire, non-endospermic, <i>Hebe stricta</i> seed. | 78 |
| Plate 4.14 | <i>Hebe stricta</i> seedlings growing towards the light. | 78 |
| Plate 4.15 | Light microscopic section of <i>Hebe stricta</i> seed. | 79 |
| Plate 4.16 | <i>Leptospermum scoparium</i> capsules. | 80 |
| Plate 4.17 | Linear <i>Leptospermum scoparium</i> embryo and seed coat. | 80 |
| Plate 4.18 | Light microscopic section of <i>Leptospermum scoparium</i> seed. | 80 |
| Plate 4.19 | Seeds of <i>Muehlenbeckia australis</i> . | 81 |
| Plate 4.20 | Trigonus nut-like achene of <i>Muehlenbeckia australis</i> . | 81 |
| Plate 4.21 | <i>Muehlenbeckia australis</i> seed cut in half longitudinally. | 81 |
| Plate 4.22 | A <i>Muehlenbeckia australis</i> seedling. | 82 |
| Plate 4.23 | Light microscopic section of <i>Muehlenbeckia australis</i> seed. | 82 |
| Plate 4.24 | <i>Myrsine australis</i> mature (black), semi-mature (red) and immature (yellow/green) fruits. | 83 |
| Plate 4.25 | Seeds of <i>Myrsine australis</i> . | 83 |

| | | |
|-------------------|---|-----|
| Plate 4.26 | <i>Myrsine australis</i> seed. | 83 |
| Plate 4.27 | Light microscopic section of partial view of <i>Myrsine australis</i> seed. | 84 |
| Plate 4.28 | <i>Phormium tenax</i> seed and capsules. | 85 |
| Plate 4.29 | Transverse <i>Phormium tenax</i> seed section. | 85 |
| Plate 4.30 | A <i>Phormium tenax</i> seedling and germinating endospermic seed. | 85 |
| Plate 4.31 | <i>Sophora prostrata</i> pods and seeds. | 86 |
| Plate 4.32 | A <i>Sophora prostrata</i> seed cut in half longitudinally. | 86 |
| Plate 4.33 | <i>Sophora prostrata</i> seed germinating on the thermogradient plate. | 104 |
| Plate 4.34 | <i>Sophora prostrata</i> seed germinated in the dark, undergone etiolation. | 118 |

List of Appendices

| | | |
|-------------------|---|-----|
| Appendix A | Hydroseeding experiment conducted winter 2002 | 138 |
| Appendix B | Cleaning descriptions and the equipment that was used for each species studied. | 142 |