AN EVALUATION OF OSMOTIC PRE-SOWING SEED TREATMENTS AS A POTENTIAL METHOD FOR IMPROVING THE GERMINATION PERFORMANCE OF *PINUS RADIATA* D. DON SEEDS

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ABSTRACT

KUSMINTARDJO, 1992. **An Evaluation of Osmotic Pre-sowing Treatment as a Potential Method for Improving the Germination Performance of *Pinus radiata* D. Don Seeds**

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This study was conducted to characterise optimum conditions for osmotic pre-sowing treatment as an effective means of improving the germination and/or emergence performance of *Pinus radiata* from different seed grades.

The results indicated that osmotic treatment could reduce the germination and/or emergence times of *Pinus radiata* seeds by 40% of controls, if treated seeds were not subsequently dried back to original moisture contents. Osmotic treatment did not alter both the uniformity and final percentage germination. Rapid germination at this rate was only obtained if seeds were treated in optimum treatment conditions, i.e. with a -1.0 MPa solution for 10 d at 20°C. The correct choice of water potential and treatment duration is crucial in determining the level of treatment benefits. At high water potential, seeds were lost due to pre-germination during treatment, while at low water potential treatment benefits were less. Treatment with salt solutions (KNO_3 + KH_2PO_4) was better than with polyethylene glycol, an effect which seemed to be a result of differing seed moisture content attained during treatment as no pre-germination occurred during PEG treatment while the moisture content of PEG-treated seeds attained following drying was less than that attained by salt-treated seeds.

Since seeds are kept in the imbibed state during treatment, the prevention of microbial proliferation is of prime importance. The use of Thiram at 1% seed weight and applied before osmotic treatment gave good protection against microbial attacks without losing treatment benefits in terms of rapid germination. Application of Thiram beyond its optimum rate should be avoided as it can delay seed germination.

Treated seed should not be dried back to low moisture contents rapidly, even at ambient temperatures (22-27°C, 50-6-% RH) as drying for 4 d in these conditions resulted in a complete loss of treatment benefit. However, slow drying of osmotically treated seeds at high relative humidity (20°C, 80-85% RH) prevented the adverse effects of desiccation on germination performance. Seed dried back in this way had 30% less in median germination times relative to untreated controls.

The response of osmotic treatment applied to different seed grades gave consistent results. Rapid germination due to osmotic treatment occurred in all seed grades at similar rates and was reflected in a significant increase in seedling dry weight. As the increases in seedling dry weight were more evident in larger or heavier seeds than in smaller or lighter seeds, it is suggested that osmotic treatment seems to influence relative growth at this stage of seedling development.

Osmotic treatment reduced the storability of seed, although applications of this treatment after storage restored the level of vigour of aged seeds which just begun to decline. Although total dehydrogenase activity in osmotically treated seeds was higher than in untreated controls, there was no difference in oxygen uptake between treated and untreated controls prior to radicle emergence. It was suggested that factors other than energy production are perhaps responsible for ensuring rapid germination of treated seeds.

The commercial implications of this study are potentially good. Osmotic treatment in tree seeds is no longer restricted to using only polyethylene glycol. Improved seedling growth as a result of early emergence can help low vigour/moderate vigour seedlings become more vigorous and meet standard specifications required for outplanting.

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I. INTRODUCTION

In the early days of forest establishment around the world, natural forests were viewed as an infinite resource to be utilised as markets demanded. Because they have not been managed sufficiently, the depletion of natural forest is inevitable. With important shifts of social and economic attitudes as well as increases in human populations, natural forests could no longer provide enough timber and other forest products.

New Zealand is no exception. Kauri, the indigenous tree, is no longer or hardly available in the market, the "kauri era" having finished a long time ago in the early 1900s. Since then the "radiata era" started to emerge as more and more timber was produced from the exotic radiata plantation (Simpson, 1973). New Zealand has perhaps the world's most intensively managed and productive forest resource. Radiata grows very well and performs better than if grown in its site of origin in central California (Roche, 1989).

Forestry in New Zealand is carried out on a huge scale by both the state-owned New Zealand Forest Service and private companies, notably New Zealand Forest Products Limited and Tasman Pulp and Paper Limited. Both these companies have extensive integrated forestry operations which include the care and development of forest stock, tree felling, timber milling, the manufacture of timber building boards, plywoods and veneers, pulp-processing and paper-making, as well as the production of other related forest products. Up until now New Zealand exports to 60 different countries. Therefore it is not surprising that timber and related products now generate about six percent of New Zealand's export earnings. These products, mainly from radiata plantations, are predicted to account for 15 percent by the end of this century when forestry production is projected to reach 300,000,000 cubic metres a year (Anonymous, 1986). This is an ambitious effort from the forestry sector.

Since seedling propagation seems to be the most efficient and economic method for plant establishment, a large number of seeds are needed for annual planting, particularly genetically improved seed from selected trees. The "268" multinodal breeds, for instance, are those trees which are considered to have fast growth, straight stems, an even multinodal branch habit, freedom from forking and resistance to *Cyclaneusma* needle cast. Similarly, the "875" breeds, despite having the same growth characteristics as the "268" breed, has higher wood density (Shelbourne, 1986).

At the moment, production from seed orchards is around 4000 kg a year which is numerically enough to supply current requirements for reforestation and afforestation throughout the country (Shelbourne, 1986), where planting activities are targeted at 40,000 hectares a year (Roche, 1989). Although seeds produced from orchards have quite high percentage germination as indicated from laboratory tests (Section 4.2.2), field performance seems to be quite low. Poor survival of planted seedlings has been reported, sometimes being less than 50% (Dale, 1981). Causes of poor survival in pine could include:

i. poor quality of planting stock;

ii. improper lifting, handling, culling, storage before planting and transportation;

iii. poor planting techniques, and

iv. unfavourable site conditions during and after planting (e.g. Rasanen, 1980; Venator, 1981; Xydias, 1980).

Poor seedling quality could be due to variation in seed size and weight, since large seeds or heavy seeds of *Pinus radiata* produces larger and more vigorous seedlings needing a shorter period in the nursery compared to those from small or light seeds. This has resulted in *Pinus radiata* seeds being sold commercially in four different seed size grades, A, B, C and D; A being the largest seed and D the smallest one. Since seedlings produced from low grade seeds very often do not survive well after planting (perhaps due to small size) and the production of large grade seeds may be limited, the long term impact of any poor survival in large scale plantations for 40,000 hectares a year would be very significant.

It has been realised that seedling growth is governed by seed size, emergence rate, available space for growth and genetic components. Nursery practice should therefore minimise the adverse effects independently associated with those factors. In loblolly pine, late emergence adversely affected seedling morphology and increased mortality from < 1% in seed emerged early to around 23% for those emerged later, while in *Pinus ponderosa* comparable figures were < 23% for early emergents to over 50% for late (Mexal and Fisher, 1987). The same effect of late emergence on seedling morphology has also been observed in larch and *Pinus caribaea* (Venator, 1973; Logan and Pollard, 1979). It is possible that the problems of low vigour and poor seedling establishment owing to late emergence may be overcome by applying pre-sowing treatments to improve seed performance as have been developed in agriculture and horticulture. Such pre-sowing treatments include hydration-dehydration methods, also called seed hardening (May *et al.*, 1962), low temperature pre-sowing treatments (Coolbear *et al.*, 1984, 1987) and osmotic pre-sowing treatment or seed priming (Heydecker and Coolbear, 1977; Bradford, 1986; Haigh and Barlow, 1987a). Significant improvements caused by pre-sowing treatments in horticultural seeds in particular include: (i) advanced germination times, (ii) reduction in the spread of germination within a seed population (Heydecker and Coolbear, 1977; Heydecker and Gibbins, 1978); (iii) increased tolerance of seeds or seedlings to adverse conditions during seedling establishment (Coolbear and McGill, 1990) and probably (iv) increased yield or plant weight (Khan *et al.*, 1980; Brocklehurst and Dearman, 1983b).

Despite the successes of using osmotic treatment for enhancing germination performance of agricultural and horticultural seeds, large scale applications have not been adopted widely. This is, perhaps, partly due to the fact that every species of seed and even individual seed lots require specific conditions for optimum results. For large seeds sown in huge amounts, the cereals, legumes and many tree seeds for example, setting up a good priming system has not been explored far enough, and other problems may also occur, such as: toxicity of osmotica, low availability and mobility of oxygen in PEG solutions (Mexal *et al.*, 1975), microbial contamination during treatments, and also problems in drying back the seed after treatment. The mechanism of improved germination performance of treated seeds is very often suggested to be the initiation of repair mechanisms during treatment, however, firm evidence underlying this hypothesis is sparse, although some biochemical changes have been reported (see Literature Review, Section 2.2.3.2).

So far no one has published on the effects of osmotic treatment in *Pinus radiata*. This study was thus designed to identify and overcome some of the problems associated with osmotic treatment which might be encountered in developing a system for *Pinus radiata* in New Zealand as well as some physiological aspects relating to the treatment. The specific objectives of the study are:

i. To characterise the best conditions of osmotic treatment for *Pinus radiata* seeds.

ii. To investigate proper drying techniques which can retain maximum benefits of treatment.

iii. To determine the effects of seed treatment on different seed grades and their effects on seedling growth.

iv. To evaluate the interactions of osmotic treatment with seed storage.

v. To conduct an investigation on some physiological aspects of osmotic treatment with particular emphasis on respiration and the activity of dehydrogenase enzymes.