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SEED TREATMENTS HAVE POTENTIAL FOR DIRECT SEEDING

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INTRODUCTION

Extreme temperature variation, flooding, drought, and the inaccuracy of seed deposition are several of the major factors that limit the success of direct seeding. Seed treatments that promote early germination and seedling establishment, control the timing of germination, enhance the microsite, or enable precision sowing may greatly assist direct seeding efforts. The concept of treating seeds has been successfully implemented in agriculture for decades. The adaptation and application of these techniques for use in extensive forest renewal programs has significant potential. As direct seeding becomes a reliable alternative to more intensive and expensive regeneration methods, relatively inexpensive and easy to apply seed treatments that lend themselves to operational use may play an important role in improving the effectiveness of seeding programs. This note is based on research and development work on various seed treatments carried out over the past decade by the Canadian Forest Service–Ontario.

OSMOTIC PRIMING

Osmotic priming (Fig. 1) is a method of seed conditioning that produces significantly faster and more uniform germination. The technique involves the soaking of seeds in an aqueous solution of polyethylene glycol (PEG) and distilled water. This solution acts as a germination barrier by preventing the seed from taking up sufficient water to germinate. By controlling the solute concentration, temperature, and duration of soaking, the seed is permitted to start initial germination processes such as the mobilization of food reserves, RNA synthesis and accumulation, and the formation of enzyme systems, but not to begin radicle emergence (Fleming and Lister 1984). Figure 1 depicts an example of the treatment apparatus; the shape and size of the treatment vessel is optional as long as the solution is aerated throughout the priming process (aerobic conditions are necessary) and the solute concentration is kept constant. About 40,000 black spruce seeds can be treated at one time using this apparatus.

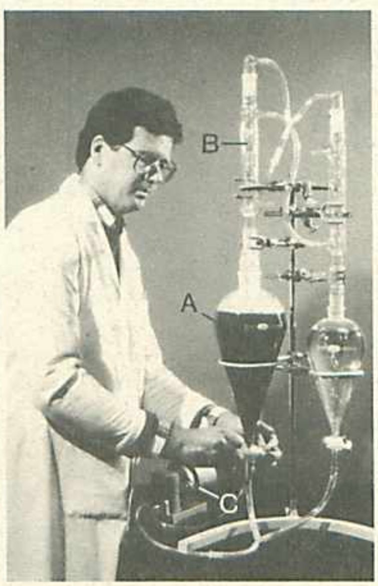

Figure 1. Osmotic priming apparatus showing the (A) treatment vessel (PEG solution and seeds), (B) condensation trap, and (C) air pump.

Results of laboratory germination trials (Fig. 2) conducted under controlled conditions show a significant acceleration in germination between treated and untreated seeds.

Osmotic priming appears to offer the greatest potential benefit under conditions where prompt germination at low temperatures is an asset. This is often the case on boreal lowland sites where cold temperatures limit seed germination and seedling growth. The ameliorating effects of a seed shelter appear to enhance this treatment and at the same time reduce the risk of late spring frost damage to new germinants. Fifth year seed spot data (Fig. 3) from field trials conducted on two peatland sites (OG 11 and 12, *Ledum* and *Alnus*–herb poor, respectively) (Jones et al. 1983) in the Cochrane District of Ontario show the potential increase in height growth that can be achieved when using "primed" seeds in combination with seed shelters.

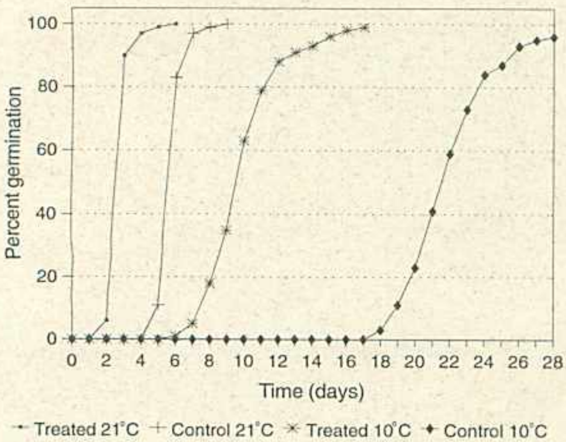

Figure 2. Effect of priming treatment on the germination speed of black spruce at optimum (21°C) and low temperatures (10°C).

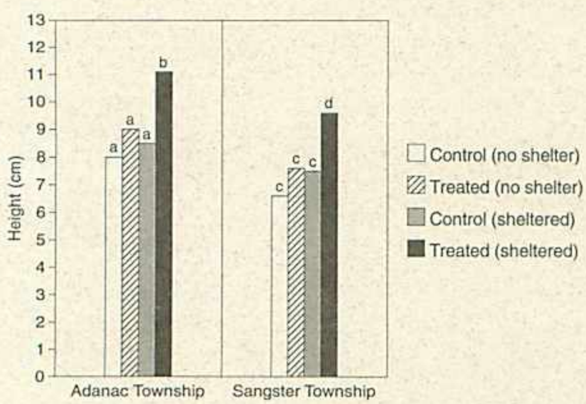

Figure 3. Average fifth year height growth of black spruce seedlings on two peatland sites, using osmotically primed seeds. Histograms identified by the same letter are not significantly different (p=0.05).

SEED COATING AND PELLETING

The very small size of black spruce (*Picea mariana* [Mill.] B.S.P.) seeds (830 seeds per gram) has traditionally made this species difficult to handle efficiently. An inert seed coating that permits the rounding and enlargement of small seeds has been used successfully for agricultural crops. This treatment facilitates precision mechanical sowing and enhances the ballistic properties for broadcast seeding. As well, it provides a vehicle for the incorporation of a variety of additives to protect or enhance early seedling establishment.

Extensive trials have been conducted at the Great Lakes Forestry Centre in Sault Ste. Marie, Ontario, to evaluate the potential of currently available commercial varieties of coated[1] and pelleted formulations in an effort to determine their suitability for use with conifer tree seeds. Many large, commercial, seed coating firms are located in the United States, Sweden, and Germany. However, dealing with foreign suppliers can be problematic (e.g., acquisition of phytosanitary certificates, added expense, and long turn-around time).

Methods, procedures, and materials used in the production of coated seeds vary greatly from producer to producer. Cooperative trials with two Canadian suppliers (P. Trussell and OSECO Inc.) were undertaken to assess the effectiveness of their coatings on the germination and survival of black spruce under laboratory and field conditions. Trussell produces pelleted seeds using either silica (320 mesh) or diatomite powder combined with a polyvinyl alcohol binder. The size of the final product can be tailor-made from a light coating to a pellet measuring 4.0 mm in diameter. OSECO Inc. produces a patented Prill-On® coated seed that increases seed weight by 30 to 50%. Their agricultural formulation contains inoculant, fertilizers, lime, and special additives that combine to protect the seed and aid in seedling establishment.

Laboratory experiments conducted at the Canadian Forest Service – Ontario indicated that delays in germination speed are directly related to the thickness of the seed coating. However, there is no significant difference (p=0.05) in the germinative capacity of untreated seeds and coated seeds having diameters of 2.25 mm or less following 21 days under optimum germination conditions. Field trials (Fig. 4) conducted at two upland black spruce sites in northern Ontario indicated that these coatings have no significant adverse effect (p= 0.05) on seed spot stocking (5 seeds per spot), either with or without plastic seed shelters.

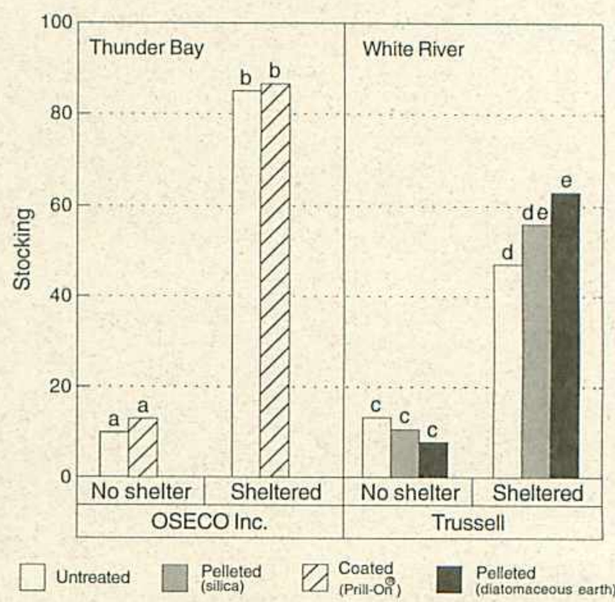

Figure 4. Second year seed spot stocking results of coated and pelleted black spruce seeds. Histograms identified by the same letter are not significantly different (p=0.05).

[1] In this note "coating" means applying a layer of material to a seed without altering its shape to any extent. "Pelleting" means applying material to a seed in such a way as to embed it in a fairly uniform spherical pellet.

SEED ENCAPSULATION

Encapsulating seeds in a tablet, wafer, or pill-like form (Fig. 5) provides an opportunity to conveniently package a predetermined number of seeds in a medium that acts not only as a carrier, but also provides a compact microenvironment favorable for germination. As with seed coating, there is a host of encapsulation products, which vary in size, shape, and consistency.

Trials by Fraser and Adams (1980) found that encapsulation using the FMC (FMC Export Corporation) formulation adversely affected black spruce germination. Similarly, Buse (1992) had unacceptable results using the experimental Dupont "seed egg". However, field trials conducted by the Canadian Forest Service – Ontario with a seed wafer developed by the University of Idaho demonstrated that the use of these seed wafers (vs bare seeded spots) increased the percentage of stocked seed spots by 4% on lowland and 18% on upland sites.

Further testing at the Great Lakes Forestry Centre determined that attaching the seed to the outside of the wafer using a polyvinyl alcohol binder was far superior to enveloping the seed within the wafer. Schwan (1991) found that orientation and depth of insertion of the wafer in the ground surface was critical. Based on these preliminary trials, and spurred on by the ease of handling and economics of the concept, QUNO Corporation, in conjunction with the Ontario Ministry of Natural Resources' Northeast Science and Technology Unit and Jiffy Products (N.B.) Ltd., is now conducting field trials to assess the effectiveness of this technique under operational conditions.

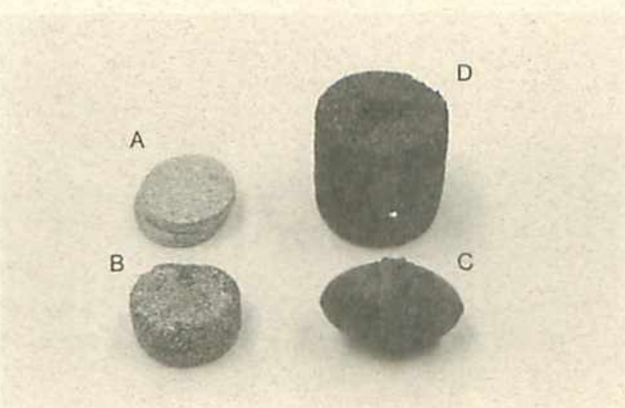

Figure 5. Examples of encapsulated seeds: (A) original FMC (single seed in a semispherical cavity of a flat, round disk formed by cementing together two identical halves of compressed vermiculite), (B) University of Idaho seed wafer (composed of seeds embedded in a tablet of a fine grade of vermiculite and activated charcoal, bound by methylcellulose), (C) Dupont "tree egg" (a blend of hydrophillic polymers, dried and pressed into a two gram, egg-shaped pellet into which the desired number of seeds is embedded), and (D) a fully imbibed Jiffy Products (N.B.) Ltd. J-9 wafer (compressed peat that has been bitumized to hold the wafer together following saturation and expansion).

MICRONUTRIENT PRESOAKING

The soaking of seeds in micronutrient solutions has proven to accelerate the germination and early growth of several European conifer species. It has been established that profound changes occur in the cell plasma of the embryo when seeds are treated with various concentrations of micronutrients. These changes determine to a certain degree the future development of the seedling. Laboratory germination trials involving black spruce seeds pretreated in micronutrient solutions such as $CuSO_4$, $ZnSO_4$, $MnSO_4$, and H_3BO_3 resulted in a significant increase in germination speed, but subsequent greenhouse trials showed no noticable increase in average height or dry weight. However, this treatment may be useful in combination with other seed treatments for use where early seedling establishment is critical.

DELAYED GERMINATION

The concept of controlling the timing of germination through the use of chemical inhibitors was investigated to address the feasibility of delaying until the following spring the germination of seeds sown in mid to late summer. This would lengthen the direct-seeding period without the risk of late-season germination and subsequent damage by fall frost. Groot (1985) tested numerous combinations of growth regulators and organic solvents. Embryo dormancy was successfully induced in black spruce (Fig. 6), but efforts to reverse the effect of the treatment through stratification, leaching, and outdoor overwintering was only partially successful. However, this research was successful in documenting an effective method of introducing growth regulators to conifer seeds via organic solvents. This may eventually lead to practical applications.

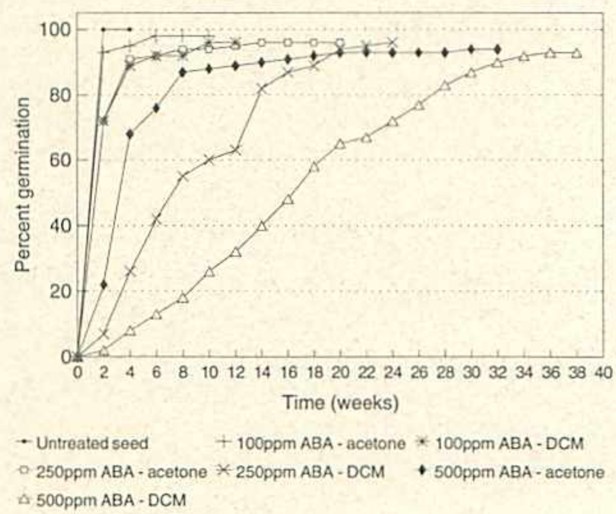

Figure 6. Effect on germination of black spruce seeds following pretreatment with abscisic acid (from *Groot 1985*).

MANAGEMENT IMPLICATIONS

Low cost regeneration methods are likely to be increasingly employed in Ontario for the foreseeable future, and direct seeding may be one such low-cost technique. Seed treatments, either individually or in combination and applied operationally, could dramatically improve the success of direct-seeding programs if appropriate methodologies could be developed. Rapid, early establishment would help seedlings better withstand mid season stress and would be especially cost-effective if used with genetically improved seeds.

The developed system would incorporate a variety of features, so that seeds:

- are preconditioned to accelerate germination;
- are encapsulated in a form that facilitates handling;
- have a ready-made microenvironment, complete with water absorbing polymers, micro- or macronutrients, and growth regulators; and
- are preinoculated with rhizobia and contained in a biodegradable seed shelter made of plastic, peat, or paper.

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