Note – Tiedonanto

Invigoration and IDS-sedimentation of Pinus sylvestris seeds from northern Finland

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Seeds with poor, anatomical development from Rovaniemi, 66°15′–66°30′: 180 m a.s.l. were conditioned using the subsequent treatments:

1. PREVAC method (5 min, 97 kPa below atmospheric pressure) for removal of mechanically damaged seeds (7 %).
2. Invigoration using incubation at controlled moisture content (30 % f.w) and continuous air supply, for 14 days at 5°C.
3. Additional water supply for 16 hours at 5°C.
4. Drying in dehumidified air until a near maximum difference in density between viable and dead seeds was obtained.
5. Separation in a sedimentation flume to achieve a gradient of fractions of different germination rate and capacity.

The treatments resulted in an improvement of germination percentage from 33 to about 95 % and a reduction in mean germination time from 8.8 days to 6 days if the control and the best fractions (32 % seeds) were compared.

Keywords: Incubation, invigoration, IDS method, PREVAC method, sedimentation, seed vigour, mean germination time, poorly developed seeds, *Pinus sylvestris*
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1. Introduction

In northern Finland as well as in northern Sweden there is a shortage of high-quality Scots pine (*Pinus sylvestris* L.) seeds (e.g. NSFP 1987).

The shortage is largely due to unsuitable temperature climate (cf. e.g. Henttonen et al. 1986) during the development and maturation of cones and seeds with the result that seeds are often killed or poorly developed and, consequently, of low vigour.

The introduction of new methods for elimination of non-productive seeds (for reviews, see Lestander & Bergsten 1985; Simak et al. 1985) and for invigoration of seeds (Bergsten 1987) has resulted in considerable improvements in seed quality. In the present work, the above methods were tested on a poorly developed seed lot from northern Finland.

2. Materials and methods

The seed sample used was provided by the Forestry Board in Rovaniemi. The seeds were collected in autumn 1986 at Rovaniemi, lat. 66°15′–66°30′, 180 m a.s.l. The anatomical potential (Simak 1980) as determined on 3×100 seeds was 84 % and indicated a poor development. About 20 % of the seeds were of embryo class I or II, i.e. with embryos shorter than half of the embryo cavity. The x-ray test (4×100 seeds) using chloroform as vaporous contrast agent (Simak 1980) indicated that some seeds were mechanically damaged. About 1 % showed clear damage (visible cracks, etc.) and almost all seeds had the small impregnation dots on the x-ray film that are typical of a minor impact. The germination test at 20°C and constant light (Jacobsen apparatus – 3×100 seeds) revealed that the germination percentage for filled seeds was 10 % and 33 % after 7 and 21 days, respectively. The ungerminated seeds at the end of germination test were subjected to cutting test (ISTA 1985). Most seeds (62 %) were dead and only 5 % were fresh.

With the above analyses as a base, the following successive treatments were considered appropriate.

I *PREVAC treatment* (Bergsten & Wiklund 1987)

Seeds in an exsiccator filled to 2/3 with water were subjected to low pressure (97 kPa below atmospheric pressure) for 5 minutes. Using a sieve the seeds were held 1–2 cm below the surface of water during the low pressure treatment. After release of the low pressure, the sunken (mainly mechanically damaged seeds) and floating (mainly undamaged seeds) were collected separately. The sunken seeds (7 %) which should be of poor quality (cf. Lestander & Bergsten 1985) were discarded. The floating seeds were dried to 5–7 % moisture content (fresh weight basis) and then subjected to:

II *Invigoration treatment* (Bergsten 1987)

The seeds (about 30 g) were placed in a tube (Ø 70 + 200 mm) with the two sidewalls made of a membrane, Polytetrafluorethylene (GORE-TEX; $1.4 \cdot 10^{-9}$ pores · cm^{-2}) which allows gas exchange. The initial moisture content of 30 % (IMC 30), which is found to be optimal for most seed lots, was adjusted by adding water in spray form according to:

$$\frac{\text{Desired fresh weight of seeds + water} = 100 \cdot \text{oven-dry weight of seeds before treatment}}{(100 - \text{desired moisture content in \%})}$$

The membrane tube was placed in an incubator (Inventum DK 10) at 5 ± 1°C and high humidity close to 100 % RH. The pores of the membrane ensured exchange of air, i.e. vapour and oxygen were supplied without disturbance from surrounding water drops. The seeds were stirred about once a day by careful shaking of the membrane tube during the 14 days incubation period. After this initial incubation, the seeds were further treated as follows:

III *Additional water supply* (cf. Bergsten 1987)

The seeds were soaked instantaneously in water and then placed between blotting paper in the incubator at 5°C for 16 hours. This treatment step was performed to increase the moisture content as much as possible (35–40 %) without losing the invigoration effect obtained in the previous step at IMC 30. A high moisture content is desired to facilitate for successful results of the following steps:

IV *Drying step* (D-step in the IDS method, Simak 1981).

The seeds were dried on a net shelf in dehumidified air (about 15 % RH, 20–25°C) in a drying cabinet. The seeds were occasionally stirred manually. The drying was performed until a near maximum difference in density between viable and dead seeds was reached.

This difference was estimated using sink test in water on samples of 50 seeds. When the percentage of floating seeds was about the same as the percentage of dead seeds according to the previous seed analysis, the seeds were separated using:

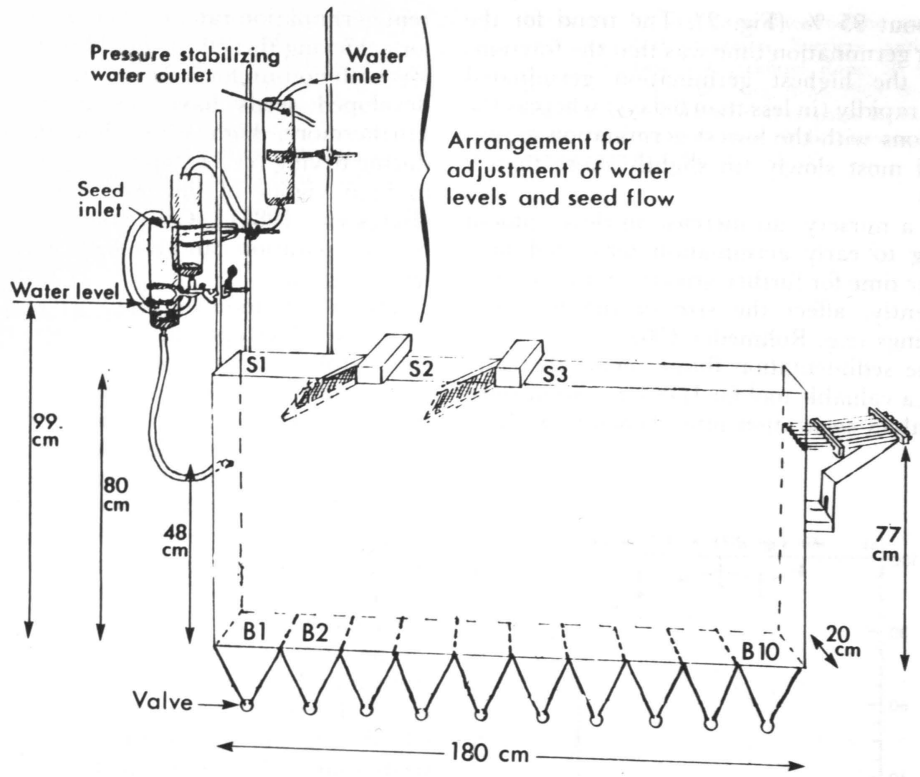

Fig. 1. Sketch of the sedimentation flume.

V *Separation in a sedimentation flume* (cf. Bergsten 1987)

The flume (Fig. 1) enabling vertical and horisontal separation consisted of ten compartments for sunken seeds (B1–B10, each with a length of 18 cm) and three compartments for floating seeds (S1: 30 cm, S2: 40 cm, S3: 90 cm). The seeds of each compartment were collected separately. In the analyses the fractions B5–B10 and S3–2 were pooled as they contained few seeds.

Seed analyses

The germination analysis (3×100 seeds) was carried out on Jacobsen apparatus at constant light (Thorn T 40 W/33 cool light; 20 $\mu Em^{-2}s^{-1}$) at 20°C for 21 days according to ISTA rules (1985) with slight modifications. Seeds with radicle of at least the same length as the seed were regarded as germinated. The seeds were all storage-dry (moisture content 5–7 %) before the germination analysis was conducted. Mean germination time (Bergsten 1987) was used as a measure of the time needed for germination. In the presented figure the standard error is described with vertical bars. Analysis of variance (GLM) and Tukey's test for multiple pairwise comparsions were used for statistical analyses according to the procedures of SAS (SAS 1985). A significance level of $p \leq 0.05$ was used throughout the experiments.

3. Results and discussion

The germination percentage of the best B fractions was improved from 33 % (control)

to about 95 % (Fig. 2). The trend for the mean germination time was that the fractions with the highest germination germinated most rapidly (in less than 6 days) whereas the fractions with the lowest germination germinated most slowly (in slightly more than 9 days).

In a nursery, an increase in development owing to early germination may lead to a longer time for further growth and may, consequently, affect the size of the first-year seedlings (e.g. Rohmeder 1962).

The sedimentation flume seems therefore to be a valuable tool for IDS separation since it enables separation into classes with different germination rate, i.e. vigour. The reason for achieving this effect should be that in seed lots with non-uniform density the most poorly developed seeds have the lowest density. Furthermore, high water holding capacity during drying (cf. D-step) seems to be related to high vigour of the seed and vice versa (Bergsten 1987). Consequently, density-based separation can give seed classes of different vigour.

The results indicate that even seed lots of very poor development may be conditioned successfully. In fact, the seed lot that untreated would be useless in a nursery, was conditioned with the result that at least 32 % (B1–B4) of the seed lot could be used for single-seed sowing in a nursery. One explanation of the good results from this experiment is that the seeds were collected quite recently. A long storage, especially under uncontrolled conditions, may give irreparable damage (cf. Simak 1986).

The effect of storing invigorated Scots pine seeds for a long time has not yet been investigated. Therefore it is recommended to treat, e.g. during the winter, only the amount of seeds that will be used up the next growing season.

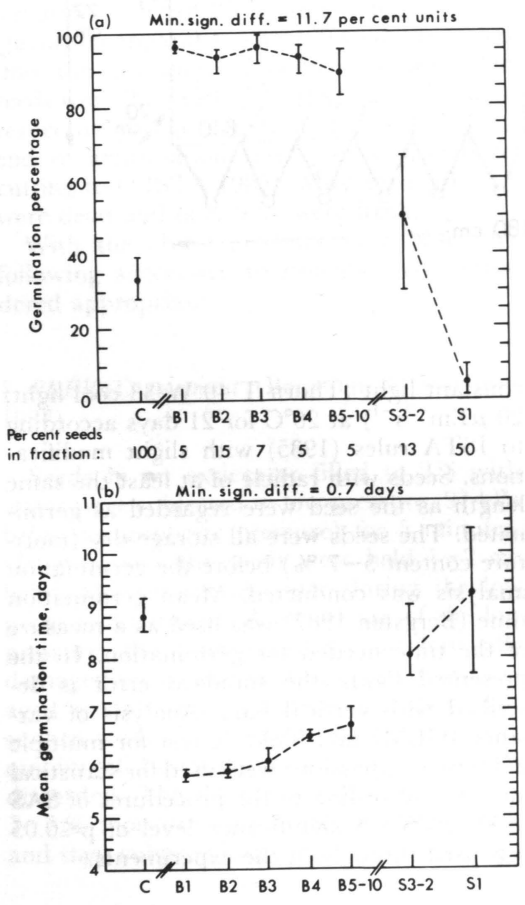

Fig. 2. Germination percentage (a) and mean germination time (b) for the B1–B10 and S3–S1 fractions after separation using the sedimentation flume. Vertical bars indicate standard error. C = control.

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Total of 12 references