Seed dormancy and consequences for direct tree seeding

H. Frochot, Philippe Balandier, A. Sourisseau

Forest Vegetation Management – towards environmental sustainability, N.S. Bentsen (Ed.), Proccedings from the final COST E47 Conference, Vejle, Denmark, 2009/05/5-7, Forest and Landscape Working Papers n° 35-2009, 43-45.

Seed dormancy and consequences for direct tree seeding

Henri Frochot[1)], Philippe Balandier[2,3)], Agnès Sourisseau[4)]

1) INRA, UMR1092 LERFOB, F-54280 Champenoux, France, Frochot@nancy.inra.fr; henri.frochot@orange.fr
2) Cemagref, UR EFNO, Nogent sur Vernisson, France
3) INRA, UMR547 PIAF, Clermont-Ferrand, France
4) Independent Landscaper, Paris, France

Key words
Afforestation, direct seeding, dormancy, seed, tree

Introduction
Whereas direct tree seeding was probably used extensively in France in the past, it is currently only employed for the reforestation of *Pinus pinaster* and some species with big seeds such as oak. Its interests are to allow a better seedling establishment and a reduced cost than with tree plantation. However many problems must still be solved. One is linked to seed dormancy (Finch-Savage and Leubner-Metzger 2006). Seeds of forest trees are frequently dormant when harvested or after a period of storage and their germination needs the release of dormancy, either by exposition to natural climate, or by artificial means when known (Willoughby et al. 2004). In the latest case pretreated seeds must be sown at a given period driven by the date of dormancy breaking, with no possibility to factor in climatic conditions. They often require specific conditions of moisture and temperature, not easy to observe in afforestation works.

Non-treated dormant seeds allow a better flexibility, especially for the date of sowing. The process of dormancy breaking by natural conditions theoretically leads to a seedling emergence during favourable soil and climatic conditions. However for most forest tree species with the exception of a few species particularly used (Suska et al. 1994), the conditions for dormancy breaking in the nature are badly known or unknown. Therefore we studied those conditions in a controlled experiment for 20 species (Frochot and Balandier 2005).

Materiel and methods
The experiment took place in the nursery of INRA Nancy (North-East France). Twenty woody species of the local flora were selected according to 3 successional stages after field abandonment:
- shrubs: *Amelanchier ovalis, Cornus mas, Cornus sanguinea, Hippophae rhamnoides, Laburnum anagyroides, Prunus spinosa, Rosa canina, Rhamnus cathartica, Viburnum lantana*
- mid-storey fruit trees: *Malus sylvestris, Prunus mahaleb, Pyrus pyraster, Sambucus nigra, Sorbus aria*
- main-storey trees : *Acer campestre, Betula pendula, Carpinus betulus, Fagus sylvatica, Fraxinus excelsior, Quercus petraea*

The seeds were not pretreated but *Fagus* as a reference and *Quercus* that was pregerminated. From the literature the dormancy profundity often expressed in months of dormancy length ranged from 0 month (*Betula*, *Laburnum*), 2-3 months (*Hippophae*, *Rhamnus*), 3-6 months (*Acer*, *Cornus sanguinea*, *Malus*, *Pyrus*, *Sambucus*, *Sorbus*, *Viburnum*), 6-10 months

(*Amelanchier*, *Carpinus*, *Prunus mahaleb*, *Prunus spinosa*) and 10-14 months (*Cornus mas*, *Fraxinus*, *Rosa*).

The seeds were sown on 1.5 m long line in spring (20-22 May) or in autumn (20-21 October) 2003, buried or not into the soil and watered/shaded (nursery method) or not, each modality being replicated 4 times. The seed number sown was calculated from data on the potential germination rate given by the seed merchants in order to have approximately 50 seedlings on each line. Seedling number and mortality was recorded every 15 (in period of active emergence) or 30 days during 3 years.

Results

Seedling emergence

Betula was eliminated from the analysis due to a very low emergence rate. The first year the species with treated seeds (*Fagus* and *Quercus*), the species with no dormancy (*Laburnum*) or weak dormancy (*Hippophae*, *Rhamnus*) and one species with a moderate dormancy (*Viburnum*) had emerged in 1 to 8 weeks after the sowing, despite the conditions of scorching heat of 2003. The second year all the species sown in spring that did not emerged the first year and all the species sown in autumn produced seedlings, with two exceptions for the autumn sowing (*Cornus mas* and *Fraxinus*) with a particularly deep dormancy.

The spring sowing had a mean emergence rate (seedling number / seed number) of 33 % (from 4 to 70% depending on the species) and that of autumn 13% (from 4 to 39%). At species level the spring sowing had always higher or at least equal emergence rates than those of autumn (table 1) and it was even 2 to 4 times higher for 6 species (*Acer*, *Prunus mahaleb*, *P. spinosa*, *Rosa*, *Rhamnus*, *Sambucus*).

Table 1. Factors affecting the seedling emergence and mortality rates of 20 species sown in nursery in Nancy, France

Factor	Modality	Emergence rate	Mortality rate
Season of sowing	Spring / Autumn	Spring >> autumn	Autumn > Spring
Modality of sowing	Buried / not buried	Buried >> not buried	Not buried > buried
Soil watering	Irrigation / no irrigation	Small or no improvement	No effect
Shading	Shading net / no shade	Small or no improvement	Small or no increase

The seedling emergence rate was higher (1 to 25 times depending on species) when seeds were buried in the soil for all species but Amelanchier for which it was equivalent. Watering the soil or shading did not improve the emergence rate except during the scorching heat of 2003 where the improvement of seedling emergence was evident.

For most species and for the most favourable conditions (spring sowing with buried seeds), seedling emergence rates were generally 1 to 4 times higher than the rates given by the seed merchants (with two exceptions *Rhamnus* and *viburnum* with a 0.5 times lower rate). The rates were even 10 times higher for *Sambucus* and *Hippophae*.

Seedling mortality

At the end of 2004 the mean seedling mortality rate was 15% (from 7 to 45% depending on the species) for the species sown in spring 2003 and 27% (from 15 to 59%) for the autumn

2003 sowing (with two exceptions *Rhamnus* and *Viburnum* with a lower mortality rate for the autumn sowing) (table 1). Improving soil water content did not affect the mortality rate. A factor that strongly increased the mortality rate was the seedling density on the line, sometimes much greater than the 50 seedlings expected (400 and 600 seedlings m^{-1} for *Hypophae* and *Sambucus*, respectively). If such densities were excluded from the analysis, the mean mortality rate was close to 10% (from 6 to 18%). The shade increased the mortality for *Rosa*, probably due to the presence of a rust favoured by the moisture under the shading net. The seeds of *Quercus* and *Fagus* sown in autumn were predated by small rodents.

Discussion

The dormancy release was generally good leading to a seedling emergence rate higher than the one given by the seed merchants. For dormancy profundity results are in agreement with data of the literature. For the seeds sown in spring, dormancy was actually broken after 10 to 11 months, including *Fraxinus* and *Cornus mas* with a very deep dormancy, whereas for the autumn sowing, with only 5 to 6 months of exposure to natural conditions, the emergence rate was lower, suggesting a partial dormancy release. However some species sown in autumn with a low dormancy profundity (3-6 months) had also a lower emergence rate; this result suggests that the alternation of drought and humidity periods during the summer could play a non negligible role in the process of dormancy release.

From a practical point of view, results are clearly in favour of a spring sowing, with buried seeds, what leads to more and healthy seedlings. The success rate varied from 2 to 58%, with a rate higher than 20% for most species, which can be used to adapt the number of seeds to sow. Species with a weak seed dormancy will emerge a few months after the spring sowing, whereas species with deep seed dormancy will emerge a year latter after dormancy breaking by the summer, autumn and winter conditions. Consequently using a mixture of species with different seed dormancy properties leads to a better flexibility in the technique of direct tree seeding. However this result must be counter-balanced in the natural conditions by the activity of rodents, particularly during winter and for the biggest seeds (De Steven 1991).

Finally, it must be underlined that the environmental conditions (light and moisture) may not have an important role on the seedling emergence stage, except for exceptional conditions as the scorching heat of 2003. However, these conditions of light and moisture become fundamental for the seedling growth after emergence (De Steven 1991; Balandier et al. 2009).

References

Balandier, P; Frochot, H; Sourisseau, A. 2009. For. Ecol. Manage. doi:10.1016 /j.foreco.2009.01.032.
De Steven, D. 1991. Ecology 72, 3: 1066-1075 and 1076-1088.
Finch-Savage, W; Leubner-Metzger, G. 2006. New Phytol. 171: 501-523.
Frochot, H; Balandier, P. 2005. Final report, SNCF, INRA, Cemagref, 76 p.
Willoughby, I; Jinks, R; Gosling, P; Kerr, G. 2004. Forestry Commission Practice Guide, Edinburgh, UK, 33p.
Suska, B; Muller, C; Bonnet-Masimbert, M. 1994. INRA editions, Paris, France, 292 p.

Acknowledgement: This research was supported by a grant of Réseau Ferré de France.