Effect of Physiological Condition at Time of Lifting

on Cold Storage Tolerance and Field Performance of Important Conifer and Broadleaf Species

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The survival and growth of seedlings[1] following planting in Ireland is sometimes poor, thus necessitating expensive replanting and/or additional post-planting maintenance. Since there has been a large increase recently in the planting of species other than Sitka spruce (*Picea sitchensis* (Bong.) Carr.), field performance has become a more important issue than in the past. Most species are more difficult to establish than Sitka spruce. The physiological (or non-visual) condition of the planting stock at the time of planting may be contributing to these problems. Furthermore, plant handling and storage practices probably have the greatest effect on physiological condition (McKay 1997).

With the financial support of COFORD and Coillte, a series of experiments was undertaken from 1995 to 1998 to determine the effect of physiological status at lifting on:

- **the field performance potential and**
- **the cold storage tolerance of**

Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), Sitka spruce, hybrid larch (*Larix x eurolepis* Henry), sycamore (*Acer pseudoplatanus* L.), ash (*Fraxinus excelsior* L.), sessile oak (*Quercus petraea* (Matt.) and beech (*Fagus sylvatica* L.)

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Introduction

Seedlings may be subjected to a variety of stresses during the period between the time of lifting and planting, including the possibility of desiccation, rough physical handling, and lack of light (Tabbush 1988; McKay 1997). Temporary storage of plants under ambient conditions for some weeks before planting, either at the nursery, in transit, at sorting depots, or at planting sites is another potential stress (McKay 1997; Harper and O'Reilly 2000). In addition, a significant proportion of seedlings are now placed in cold or freezer storage for a period before planting. While the use of cold storage allows flexibility

[1] *Seedling is used in the broad generic sense to include all types of planting stock, including transplants.*

in scheduling lifting and planting operations, the physiological condition of seedlings may deteriorate during storage. This has been implicated in some plantation failures.

The physiological status of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), hybrid larch (*Larix x eurolepis* Henry), Washington origin Sitka spruce (*Picea sitchensis* (Bong.) Carr.), ash (*Fraxinus excelsior* L.), beech (*Fagus sylvatica* L.), sessile oak (*Quercus petraea* (Matt.) and sycamore (*Acer pseudoplatanus* L.) seedlings at the time of lifting was assessed periodically from October to May over several years. The effect of cold (1°C) storage from the date of lifting until May on plant quality was also investigated. The field performance of seedlings that were planted in a field trial concurrently with the physiology work was evaluated.

Materials and Methods

None-so-Hardy Nursery, Ballymurn, Co Wexford, and the Coillte nurseries at Camolin, Co Wexford and Ballintemple, Co Carlow supplied the planting stock used in the study. Seedlings were lifted and dispatched at 2-5 week intervals from October to May from 1995 to 1999. Some seedlings were placed in cold (1°C) storage from the date of lifting until May. Other seedlings were planted soon after lifting or after cold storage until May in a field trial at Kilmacurra, Co Wicklow. Physiological development of the plants was followed using cold hardiness (conifers only), shoot water potential (broadleaves only), dry weight fraction of shoot tips, root electrolyte leakage (REL) and root growth potential (RGP) (Ritchie 1984; McKay 1997; O'Reilly *et al*. 1999a, 1999b, 2000a, 2000b). Cold hardiness is often used as a measure of the degree of stress resistance or dormancy achieved by seedlings. Shoot water potential and dry weight fraction of shoots are measurements of seedling water status, and values often vary seasonally. REL is a measure of root membrane function; high values indicate that the plants are damaged or highly active. RGP is a measure of the seedling's ability to initiate roots in a favourable environment.

Results and Discussion

Only the main findings of the study are summarised, but more detailed information is provided elsewhere (Mortazavi 1999; O'Reilly *et al*. 1999a, 1999b; 2000a, 2000b; Harper and O'Reilly 2000; Colombo et al. 2001). For conifers, cold hardiness levels, which gave a good indication of readiness to lift or cold store plants (Table 1), were determined. Root electrolyte leakage values could be used to augment this information and to assess post-storage vitality, although it was less useful to this end for Douglas fir (Table 2). Most of the physiological parameters used were of more limited use in determining safe lifting windows for the broadleaves. Benchmark REL values that indicate readiness for lifting the broadleaves for field planting or cold storage were determined (Table 2), but REL was not useful in judging post-storage quality.

Table 1: Benchmark shoot cold hardiness levels for the safe lifting of Douglas fir, larch and Sitka spruce seedlings.

	Cold hardiness LT_{50} value (°C)	
Species	**Freshly lifted**	**Cold stored**
Douglas fir	-10	-20
Hybrid larch	-15	-20
Sitka spruce	-20	-30

Notes :
[1] LT_{50} values are the temperatures at which 50% of needles were killed in a series of controlled freeze tests.
[2] All the above are for field planting and for cold storage until May.

Table 2: Benchmark REL values for the safe lifting of several coniferous and broadleaved seedlings.

Conifers			**Broadleaves**	
Root electrolyte leakage (REL) %				
Species	Freshly lifted	Cold stored	**Species**	Cold stored
Douglas fir	see note 1	<25%	**Ash**	<20%
Hybrid larch	<30%	<20%	**Beech**	<30%
Sitka spruce	<20%	<15%	**Oak**	<30%
			Sycamore	<30%

Notes:
[1] Not reliable for Douglas fir.
[2] All the above are suitable for field planting and/or cold storage until May.
[3] The test did not provide useful information on lifting broadleaves for fresh planting.

The optimum periods for lifting seedlings for field planting or cold storage were determined (Figure 1), although these results must be interpreted with some caution since only one field trial was used. Periods of less certainty are also highlighted. During these periods, actual field performance will vary depending on year, handling stresses experienced by the seedlings prior to planting, and post-planting field conditions. For stock freshly lifted during these periods, good success can be expected if the seedlings are planted soon after lifting. Although seedlings of all species could be safely cold stored, Douglas fir, sycamore and beech appeared to be sensitive to storage some years. The period of cold storage should be kept short for these species, perhaps until April rather than May.

Some species, such as Douglas fir and sycamore, should be planted early (October–December) in the season, when the soil is warm and/or the seedlings have good root growth potential. Although survival was generally very high, regardless of lifting date or cold storage treatment, shoot dieback was a common response in all broadleaved species, especially in oak, and in sycamore to a lesser extent. In some cases height growth was reduced slightly by this dieback, but the potential effect on stem quality may be large (and may require formative shaping). Planting during the period recommended here greatly reduced the frequency of dieback. The field performance of beech was an exception to this trend; late season (about March onward) planting may also cause mortality.

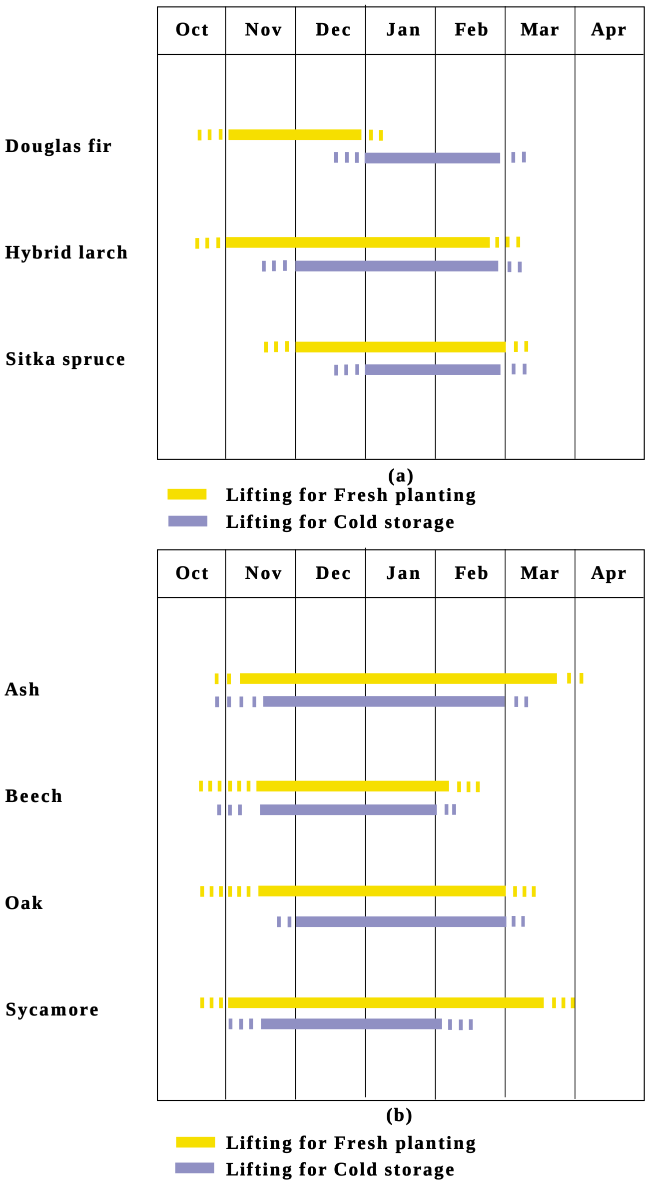

Figure 1. Recommended dates of lifting (a) conifers and (b) broadleaves for field planting or cold storage. (Discontinuous lines indicate period of less certainty)

The biggest risk in planting seedlings early in the planting season (recommended for Douglas fir and sycamore only) is that the plants are not highly stress resistant and may suffer from damage during handling, or while in temporary storage prior to planting. Nevertheless, Douglas fir can be safely stored under ambient environmental conditions (in the shade) for about 12–19 days during the October to December period (Harper and O'Reilly 2000), but the duration of safe storage may be much shorter in some years than in others (especially in October) and at mild coastal locations. Ground preparation (e.g. mounding) and other treatments that are likely to lead to an increase in soil temperature may also increase the success of Douglas fir after planting. Douglas fir should be planted when soil temperatures exceed 5 °C in the autumn / early winter. However, seedlings are more prone to handling damage when lifted late (March onward) in the season, and some species have a low natural potential (even if handled carefully) to become established when planted during this period. Much field planting in operational forestry in Ireland is undertaken from about March onward, which is outside the period recommended for most species (Figure 1). This may be a major contributing factor to the poor field performance of many species, leading to plantation failures in some cases (especially in beech and Douglas fir).

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