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**RECOMMENDED PLANT TYPE AND LIFTING DATES FOR DIRECT PLANTING AND COLD STORAGE OF BARE-ROOT DOUGLAS FIR IN BRITAIN, by Helen McKay and Bobby Howes**

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**Summary**

Douglas fir is difficult to establish but correct nursery and storage techniques can improve survival. In 1990, 1991 and 1992, autumn planting gave very variable survivals whereas spring planting was more consistent and gave slightly greater survival. The recommended period for lifting and direct planting is mid-January to the end of March. Comparatively short-term storage at +2°C was possible with survivals of >80%. The recommended period for lifting to +2°C storage is mid-January to mid-March with planting before the end of April. Storage at +2°C resulted in better survival than sub-zero storage.

**Introduction**

1. Douglas fir is one of the most difficult commercial conifers to establish in Britain. This can be due to frost or desiccation damage to the shoot after planting but poor survival and growth also result from damage caused during storage prior to planting. The roots of Douglas fir are especially sensitive to damage during cold storage (McKay and Mason, 1991; Sharpe and Mason, 1992; McKay, 1993), desiccation (Tabbush, 1987; McKay and White, in press) and frost (McKay, 1994). Since the tolerance of Douglas fir to these stresses is strongly influenced by environmental factors (Hermann, 1967; McKay and Mason, 1991; McKay, 1994), the correct choice of lifting date is central to achieving good establishment. The lifting dates most recently recommended (Tabbush, 1988) are based on typical patterns of root growth potential. In this Note we present data on the performance of seedlings from a series of replicated outplanting experiments that examined the effect of lifting date on survival and growth after both direct planting and cold storage.

**Methods**

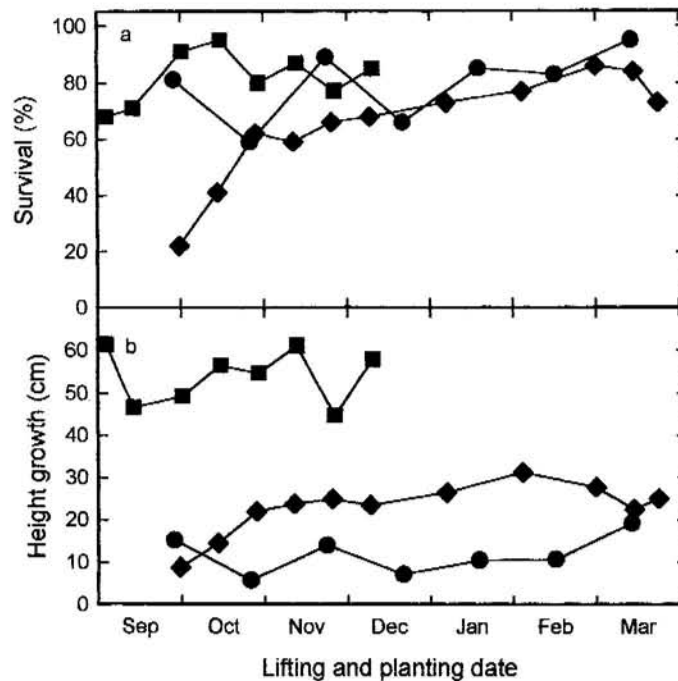
2. This Note summarizes data from nine experiments using two-year-old bare-root stock raised at Wykeham and planted between 1988 and 1993 on the North York Moors. One experiment compared transplants (1+1) with undercut and wrenched stock (1u1) but in all other experiments only 1u1 stock was used. All experiments were planted on cultivated second-rotation sites following a split plot design with five blocks split firstly for lifting date and then for species and, where appropriate, plant type. Each sub-plot had 20 seedlings giving a total of 100 seedlings per treatment combination. Details of methods and results are given elsewhere (McKay and Mason, 1991; McKay, 1993).

**Results**

3. The survivals after two growing seasons were very variable and rarely greater than 90%, therefore the advice in this Note concentrates on ways of maximizing survival, with height and diameter increments as secondary considerations.

***Direct planting***

4. Survival was variable, both from month to month and from one year to another (Figure 1a). Monthly variation was particularly evident in 1992-93. Planting in October and November was unreliable. For example, planting in early October 1990 gave good survival but satisfactory establishment following autumn planting was not achieved in either of the two following years. In both 1991-92 and 1992-93, spring planting seemed to be associated with greater survival than autumn planting. The optimum planting time in 1991-92 was early March (86% survival on 3 March and 84% on 17 March) while in 1992-93 planting from mid-January to mid-March gave >80% survival. There was no consistent effect of lifting and planting date on height increment (Figure 1b) but in 1990 height increment was two to three times greater than in the following two years.



**Figure 1** The survival (a) and height growth (b) of Douglas fir undercut stock two years after direct planting (i.e. with no intervening period of storage) on the North York Moors in 1990 (■), 1991-92 (◆), and 1992-93(●). Mean of five 20 plant plots.

### Cold storage

- Undercutting and wrenching dramatically increased the survival of Douglas fir stored on dates between October and March with outplanting in early April (Table 1).
- Storage at  $-2^{\circ}\text{C}$  was generally detrimental compared to  $+2^{\circ}\text{C}$  storage across a range of storage dates (see Table 2).

**Table 1** The second-year survival (%) of undercut and wrenching (1u1) and transplanted (1+1) Douglas fir following cold-storage ( $+2^{\circ}\text{C}$ ) on different dates and outplanting in April. Means of five 20 plant plots.

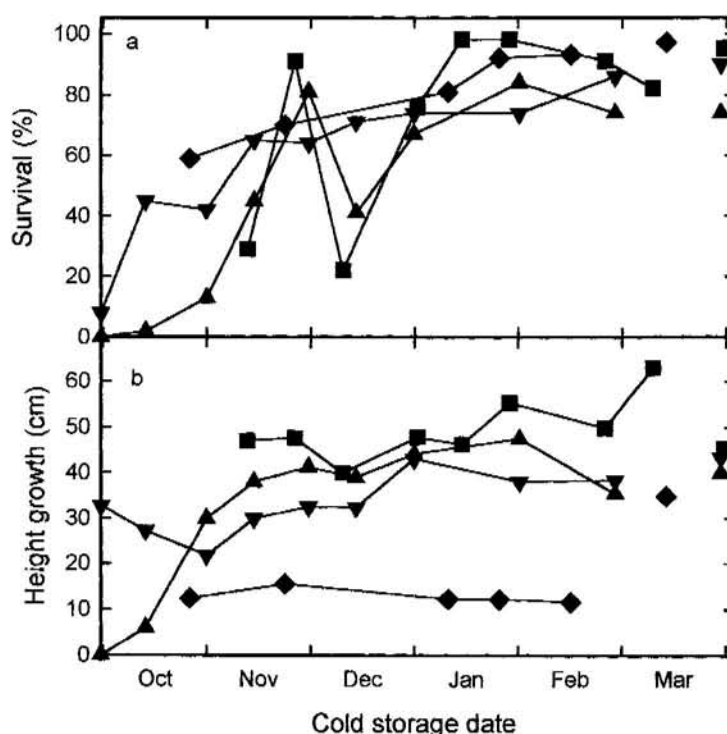
Planting year	Plant type	Storage date									
		Oct 1	Oct 15	Nov 1	Nov 15	Dec 1	Dec 15	Jan 1	Feb 1	Mar 1	Apr 1*
1989	1u1	0	2	13	45	81	41	67	84	74	74
	1+1	0	2	10	15	15	49	43	27	58	54
1990	1u1	8	45	42	65	64	71	74	74	86	90
	1+1	0	2	0	1	11	1	24	3	55	68

\*Stock without storage planted on 1 April for comparison with cold-stored stock.

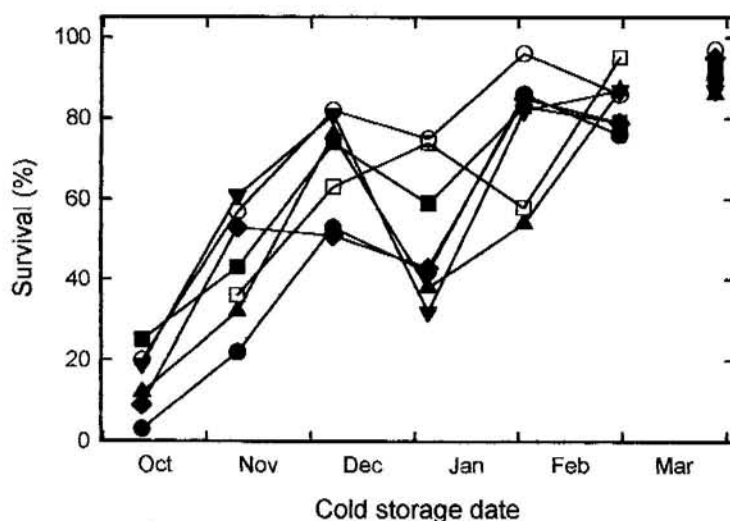
**Table 2** The second-year survival percentage of undercut and wrenching stock after storage on different dates at  $+2^{\circ}\text{C}$  or  $-2^{\circ}\text{C}$  and outplanting in early April. Standard error of the difference = 7.2. Means of five 20 plant plots.

Storage temperature	Storage date					
	Oct 27	Nov 24	Jan 11	Jan 26	Feb 16	Mar 16
+2	59	70	81	92	93	97
-2	5	70	82	72	64	83

7. Storage of undercut and wrenched stock at +2°C in October, mid-November, and December resulted in poor or inconsistent survival (Figure 2a). In general, storage beginning in mid-January to mid-March with April planting gave >70% survival. Satisfactory survival (i.e. >90%) was achieved only occasionally. Height growth over two years of cold-stored undercuts lifted in January to March and planted in April varied between 30 to 50 cm except in 1992-93 when growth was generally less than 15 cm.
8. A comparison of the survival of seven provenances from northern Oregon to northern Washington raised under the same conditions and cold-stored at +2°C on a range of dates suggests that no provenance can be safely stored (i.e. giving >80% survival) before February (see Figure 3).



**Figure 2** The effect of lifting and cold-storage date on the survival (a) and height increment (b) of undercut Douglas fir two years after planting on the North York Moors plus stock directly planted in April 1988-89 (▲), 1989-90 (▼), 1990-91 (■), and 1992-93 (●). Mean of five 20 plant plots.



**Figure 3** Survival of undercut Douglas fir of seven seed origins (Centralia, Washington (●), Matlock, Washington (■), Naselle, Washington (▲), Zone 52, N.W. Oregon (▼), Mount Vernon, Washington (◆), Sauk River, Washington (□) and Zone 412, Central Washington (○)) two years after planting following cold storage on six dates and outplanting in late March plus direct planting in late March. Mean of five 20 plant plots.

9. It was not possible to store Douglas fir safely through to early summer. Seedlings were stored at +2°C from November, January and March until May or June but no combination of lifting and planting date gave survival of >80% and there was no height growth during the first growing season. Data are not presented in detail.

## Discussion

10. Douglas fir proved to be difficult to establish, even with very careful handling and planting, and with transport distances of less than 5 km to a cultivated site. This confirms the traditional view and results from many experiments in Britain with both freshly-lifted (Mason *et al.*, 1989) and cold-stored stock (Sharpe *et al.*, 1990; McKay and Mason, 1991). Optimum lifting times are limited and even these did not consistently give >90% survival. The best survival of freshly-lifted undercuts was in the first half of March but late January and February were only slightly less satisfactory. Long-term storage even of undercut stock at +2°C resulted in poor survival whereas storage for less than three months was possible (i.e. lifting in January up to mid-March) for stock planted in April, with >70% survival. Storage during this period (January to mid-March) with later planting (in May or June) resulted in poor survival and growth. On the basis of other experiments, storage of less than one month is generally recommended (McKay, 1993).
11. These results confirm Tabbush's recommended lifting dates in spring for both direct planting and for cold storage. However, there are two points where our results disagree with existing recommendations. Firstly, current recommendations include direct planting in October and November but the results of autumn planting of Douglas fir in our experiments were not consistently satisfactory even though it may be possible to achieve good survival in some autumns. Secondly, current recommendations include planting of cold-stored stock until mid-May or, in colder areas, late May but our experiments suggest that, even when stock is stored in its prime physiological condition, planting as late as mid-May may not give good survival or growth.
12. The results permit a comparison of the performance of undercut and wrenched stock following direct planting versus cold storage during November and December 1990 and from October 1992 to mid-February 1993. In 1990, survival and height growth of stock planted directly in November and December was better than the performance of stock stored during November and December but in 1992-93, during the recommended lifting period of mid-January to mid-March, cold-stored stock performed slightly better. Statistical comparisons are not valid for 1992-93 since plants for direct planting and for storage were lifted on different dates.
13. Douglas fir that had been undercut and wrenched outperformed transplanted stock. This has been observed in many other experiments. The main benefits of undercutting and wrenching are thought to be an increase in the root:shoot ratio (Deans *et al.*, 1989) and an increase in the stock's ability after transplanting to conserve water (Rook, 1969) and produce new roots (Rook, 1973).
14. Douglas fir is a particularly sensitive species (see paragraph 1); the underlying cause may be the comparatively high level of root activity maintained over winter (see McKay and Mason, 1991; McKay, 1993). Additional reasons for this sensitivity are an inability to use stored carbohydrate (Philipson, 1988) or to produce adventitious roots.
15. The recommended period for lifting and direct planting is mid-January to the end of March and for lifting to +2°C storage is mid-January to mid-March with planting before the end of April. The earliest recommended time for lifting is likely to be similar in most years and for most nurseries and normal planting sites. On the other hand, the latest recommended time will vary with the climate (especially soil moisture, temperature and sunshine) of the nursery and planting site; in general, the latest recommended lifting and planting dates should be earlier in more southerly and westerly areas.

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