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Overwinter Physiology and the Practical Implications for Handling of Bare-Rooted Silver Birch Seedlings

INFORMATION NOTE

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SUMMARY

Bare-root undercut and wrenched silver birch had very good survival over a wide range of lifting dates when either planted directly or stored at +2ºC until March. Survivals of 95% and greater after 3 years were achieved with lifting dates from mid-October to late March. This is attributed to a high RGP, low root electrolyte leakage, excellent ability to withstand cold-storage particularly when stored early in the winter, and good root frost hardiness. The main difficulties in establishing silver birch are likely to be frost damage to shoots in spring, since the buds flush early, and root desiccation between lifting and planting, since the roots are exceptionally fine and there is relatively little woody root.

INTRODUCTION

1. There has been a rapid increase in the area of silver birch (*Betula pendula* Roth) planted in upland Britain over recent years. Silver and downy birch (*Betula pubescens* Ehrh.) account for 13 and 24% respectively of all broadleaved planting under the Woodland Grant Scheme averaged over 1993–1997. Recent initiatives such as Highland Birchwoods have been set up with the aim of increasing the area of birch woodland.

2. Published distribution maps suggest that silver birch is present throughout Britain (Souter and Peterken, 1989; Perring and Walters, 1990) but Burnett (1964) and Gimingham (1984) state that it is less frequent in northern and western areas than further south and east. Worrell and Malcolm (1998) found that it was virtually absent from large areas of western and southern Scotland.

3. Birch has the reputation for being difficult to establish (McRobbie, 1991 – see Lorrain-Smith and Worrell, 1992; Brodie, 1991). However, Morgan *et al.* (1995) concluded from 12 research experiments that high levels of success can be achieved with appropriate cultivation, good plant quality, good weed control and planting dates between February and June.

4. This Note summarises information on the physiological changes during 1994/95 in 2-year-old bare-root silver birch grown at Wykeham Nursery. The outplanting performance of stock planted without storage at different times during winter 1994/95 and of stock planted in April after cold storage at +2ºC is also reported.

METHODS

5. Seed of unknown Scottish origin was finely hand broadcast in Wykeham Nursery (0º32´W, 54º16´N, 215 m altitude) in spring 1993 and raised as undercut and wrenched (1u1) stock following Mason (1994). Plants were lifted from the nursery on 10 occasions from mid-September to late March. On each date, 85 plants were chosen for immediate quality testing and 100 for immediate outplanting (5 plots each with 20 plants). On all but the last date, 150 plants were also bagged and placed in cold storage at +2ºC until late March when 100 were chosen for planting (5 plots each with 20 plants) and 50 allocated for quality testing. Plants had a mean height of 47.3 cm and diameter of 4.7 mm.

6. On each lifting date the following tests of plant condition were made: membrane function of the fine roots by root electrolyte leakage (REL) (McKay, 1992); sensitivity of the fine roots to desiccation (McEvoy and McKay, 1997a); root frost hardiness (McKay, 1994); root growth potential (RGP) (Tabbush, 1988); bud lignification; and bud dormancy (Nielsen and McKay, in preparation). REL and RGP were also measured when plants were removed from cold storage.

7. The planting site was at North Moor, 5 km from the nursery, on a second-rotation site at 155 m altitude. The soil was an iron pan over mid-calcareous Jurassic Grit with a soft limestone lithology. The site was ploughed to 45 cm and ripped to 60 cm.

RESULTS

Differences mentioned are significant with $P<0.05$ unless otherwise stated.

Freshly lifted plants

8. In freshly lifted plants, REL fell from 20–25% in September and early October to about 12% in early November; this level was maintained until late March (Figure 1a). RGP was low in September and October but increased steadily to over 100 in January (Figure 1b). RGP remained very high until the last testing date in late March. The damage caused to fine roots by a standard desiccation treatment decreased gradually to a minimum towards the end of January before increasing slightly again over the following 2 months (Figure 1a). Root frost hardiness also increased gradually from September when the temperature causing 50% REL was -4.5ºC until late January when the damaging temperature was -10ºC (Figure 1c). The root system then dehardened to reach a damaging temperature of -7ºC by late March. Bud dry matter was already high in September (41%) and continued to increase until mid-January (47%) but then decreased gradually to reach 44% in early March and finally more rapidly to reach 37% by late March (Figure 2a). In September, the terminal buds required about 150 days of good conditions to flush but as plants were exposed to cold conditions in the nursery this declined rapidly to reach <30 days by early November (Figure 2b). The days required for bud burst fell steadily and by mid-February the terminal buds flushed after only 5 days in a warm glasshouse.

Stored plants

9. When plants were tested after cold-storage, RELs were <20% for all lifting dates (Figure 1a). Values decreased from 20% in plants stored in mid-September to a minimum of 11% in plants stored from November before increasing to 15% in plants put into storage in December, January, February and early March. After storage, RGPs were >100 for all lifting dates (Figure 1b). RGP increased as lifting and storage was delayed, reached a maximum when plants were stored in November, and declined gradually as storage was delayed further.

Survival

10. Survival after outplanting was high for all lifting dates averaging over 95% for both direct planting and cold-storage after the first growing season (Figure 2c). Survival of both freshly lifted and cold-stored plants improved as lifting for planting or storage respectively was delayed. Although the effect of lifting date was not statistically significant in the first year, plants lifted and planted directly or cold-stored on September 20 continued to die so that lifting date had a significant effect on survival in year 3. Survivals of 100% were achieved when plants were lifted in December and early January and either planted directly or cold-stored until late March. Later lifting dates were associated with slightly poorer survivals but >95% was achieved on all dates with the exception of late January. With the exception of plants lifted on 20 September, high levels of survival were maintained for at least 3 years.

Growth

11. Early lifting dates were associated with poor height and diameter growth in the first year but there was no effect in later years and by the third year after planting there was no effect of lifting date on height. First year growth of cold-stored plants was poorer than growth of directly planted stock and this difference was still evident after three growing seasons.

DISCUSSION

12. Excellent survival and growth of directly planted stock was achieved using 1u1 birch confirming findings of Morgan (1992), and Morgan *et al.* (1995) with 2-year-old, bare-rooted transplants (1+1) and one-year-old cell-grown (1+0) birch. The high survivals in the present experiment were obtained for a wide range of lifting dates; after the first year >90% survival was obtained with dates from mid-October to early March and this survival was maintained for a further 2 years. This suggests that successful establishment is possible with even earlier direct planting than suggested by Morgan *et al.* (1995).

13. In general, resistance to a range of stresses increases as cell activity decreases (Ritchie, 1989). In the present experiment, there was early and complete inactivity of both shoot (as indicated by bud dry matter and days to bud burst) and root (as indicated by REL); moreover desiccation resistance increased rapidly in September-October. These attributes may explain the excellent survival of directly planted seedlings.

14. A second reason for birch's high survival is its very high RGP which suggests that given favourable conditions after planting root growth will be abundant thereby stabilising the seedling and increasing water and nutrient availability rapidly. The fine roots of birch *(Betula pubescens)* have a very small diameter (Insley and Buckley, 1985) so the original nursery root system has a high surface area for uptake of water and nutrients. Furthermore birch has a high proportion of fine to woody roots (McKay *et al*., 1999) so it has many potential growing points.

15. Survival after cold storage at +2°C until March was excellent. This corroborates findings for bare-rooted 1+1s and cell-grown 1+0 stock stored on dates from November to March and planted in March and late May which gave 98 and 94% survival respectively after one year (Morgan *et al*., 1995). Indeed in the present study survival of plants lifted in September and October was improved by storage at +2°C compared to directly planted stock. This improvement in survival was consistent with improvements in both REL and RGP in storage. It is possible that chill storage induces acclimation responses normally caused by low temperatures in the nursery.

16. The fine root system of silver birch became increasingly frost hardy from September to January. It is almost as frost hardy as Sitka spruce and larch and much harder than Douglas fir, Scots pine, and Corsican pine (McKay, 1994); it is also hardier than most common broadleaved species (McEvoy and McKay, 1997b). This suggests that silver birch could be successfully stored at -2°C provided the root system was inactive, e.g. in December, January and February.

17. In the present experiment, careful handling and small transportation distances from nursery to planting site minimised the potential dangers normally associated with early and late handling in commercial operations when the plants are not fully inactive. Although desiccation resistance of birch did increase during autumn, desiccation can be very damaging to birch: very fine roots dry out quickly since the rate of drying is inversely related to diameter (Coutts, 1981). Furthermore birch seedlings have little woody root to act as a reserve of water or carbohydrate if the fine roots are killed. Potential damage between lifting and planting from desiccation in particular should be minimised.

18. The buds of fully chilled birch flush very quickly. Newly emerging foliage is at a greater risk of frost damage than in species which take longer to flush. Sites and management practices should be chosen to minimise the risk of frost damage to birch shoots.

CONCLUSIONS & PRACTICAL RECOMMENDATIONS

19. • Our findings suggest that birch should be easy to establish with a range of lifting dates, storage dates and plant types given normal weed control and cultivation. Root desiccation between lifting and planting or frost damage to the shoot after planting are probable causes of poor establishment.

- Silver birch can be lifted between early October and late March and planted directly or cold-stored at +2°C for planting in March. Plants lifted between December and February can probably be successfully stored at -2°C until March.

- Fine roots are abundant giving it a high RGP. However the very small diameter of birch's fine roots and lack of woody root make it liable to root desiccation.

- Birch is tolerant of cold-storage and appears to benefit from storage at +2°C when lifted in September and October.

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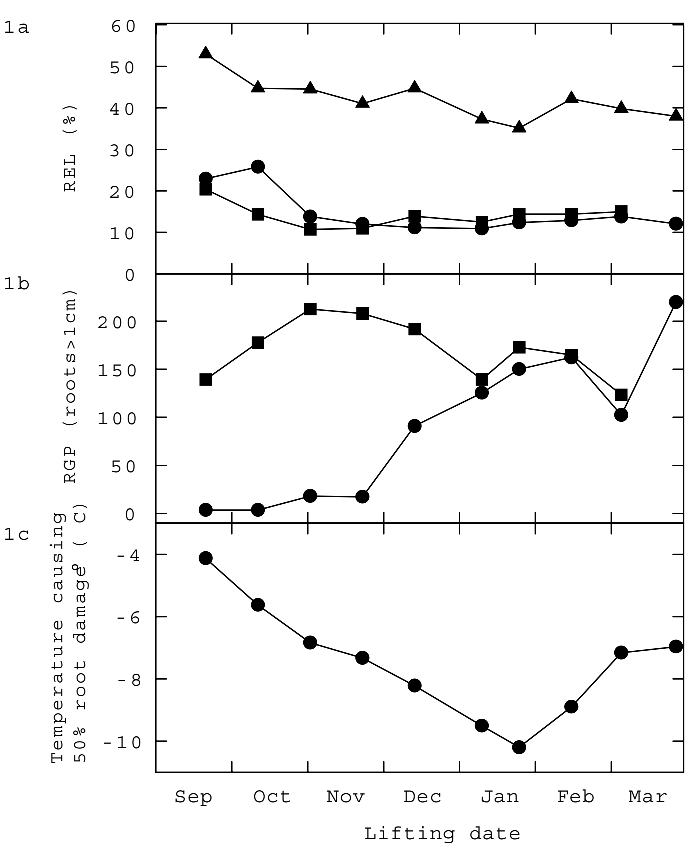

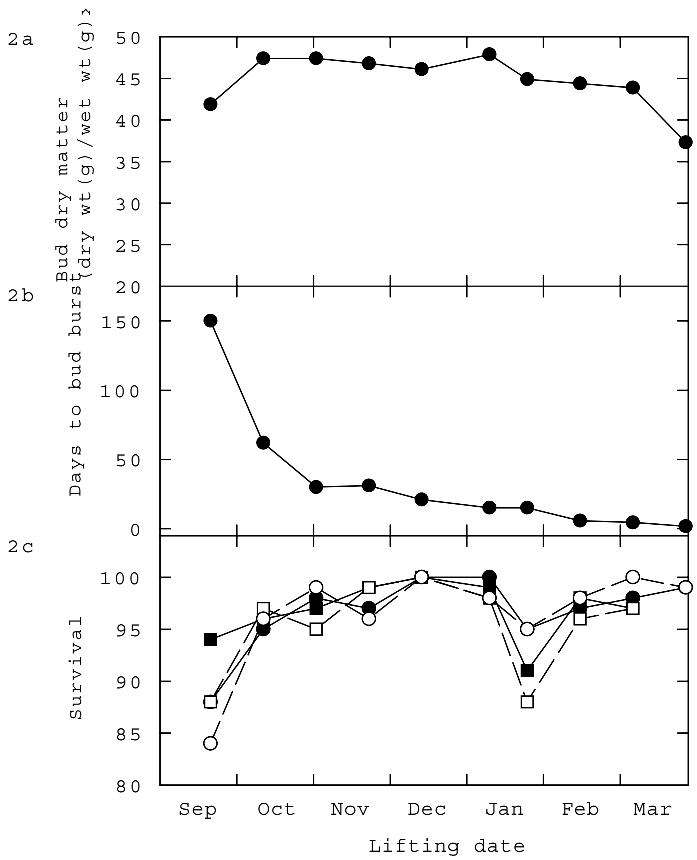

Figure 1a
Fine root electrolyte leakage at lifting (●), after desiccation within one week of lifting (▲), and after storage at +2°C until March (■), expressed as the leakage after 24 hours as a percentage of leakage after autoclaving.

Figure 1b
Root growth potential at lifting (●), and after storage at +2°C until March (■) expressed as the number of new roots >1 cm long produced in 2 weeks.

Figure 1c
Root frost hardiness at lifting assessed as the temperature causing 50% fine root electrolyte leakage.

Figure 2a
Bud dry matter of the terminal 2 cm including bud expressed as dry weight/fresh weight x 100.

Figure 2b
Dormancy of the terminal bud assessed as the number of days for the terminal bud of at least half the plants to flush when grown in glasshouse at 20°C with 16 hour days.

Figure 2c
Survival (%) of seedlings planted directly on each lifting date after one (●) or 3 (O) growing seasons, or planted in early April after storage at +2°C on different dates at the end of the first (■) or third (□) growing seasons.

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