Birch seedlings can be grown to plantable size in one year using cloches in the nursery

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Abstract

Seedbed covers were evaluated to determine if they could be used in the nursery to grow birch (*Betula pubescens* Ehrh.) seedlings to plantable size in one growing season. The effects of four different seedbed covers (a spun-bonded polyester fabric cloche, a non-perforated cloche, a perforated clear polythene cloche, and a 'floating' polythene mulch) on seed germination of birch after sowing in March, April and June and on subsequent seedling growth were investigated. Seedbed cover type had no consistent effect on germination, suggesting that all provided favourable conditions for germination. Bed cover type also had no significant effect on seedling density at the end of the growing season, suggesting that plant survival was not influenced by cloche type. However, up to 53% of the seedlings reached target size dimensions (>40 cm tall and 4 mm diameter) under the perforated cloche, compared with a maximum of 35% under the fleece cloche, suggesting that the use of the perforated cloche might be economically viable in the nursery. Germination was better for seeds sown in March than on other dates and seedling density was highest in these beds at the end of the season. Seedlings derived from seeds sown in June and under the mulch grew poorly. Sowing date and seedbed density had no significant effect on seedling morphological quality.

Keywords: Germination, seed dormancy, seedling density, morphology, plant quality.

Introduction

The current Irish target is for broadleaves to account for 30% of new plantings. In Ireland, birch (*Betula* spp.) forms an important part of this planting programme. Common birch (*Betula pubescens* Ehrh) accounts for about 85% (data on file, Coillte) of the birch planted, with the remainder being silver birch (*Betula pendula* Roth). It takes two years to produce birch planting stock (> 40 cm tall and 4 mm diameter) in Irish nurseries, whereas equivalent sized stock can be produced within one year in continental European nurseries. In fact under Irish conditions, birch seedlings are usually only about 10 cm tall (range 6-12 cm) at the end of the first growing season (data on file).

Seed pre-treatments, sowing date, nutrient regime and other nursery cultural practices can be modified to maximise germination and growth of seedlings in the nursery, but it is more difficult to influence environmental factors such as temperature, CO_2 concentrations and humidity levels. Broadleaf species appear to be particularly sensitive to environmental factors (Mason 1994). Research carried out in

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Britain has revealed that 'floating' mulches and cloches (which increase temperature and humidity but reduce exposure) can be used to improve seedbed microclimate, and thus improve growth and yields in the nursery bed (Thompson and Biggin 1980, Thompson 1982, Stevenson and Thompson 1985). Floating mulches are lengths of polythene or fabric that are laid flat on the surface of the bed, whereas cloches are similar materials raised off the bed, usually supported by wire hoops (similar to bird netting) (Mason 1994).

Results of studies conducted on several conifer species showed that germination, growth and seedling survival is favoured by using cloches (Thompson and Biggin 1980, Thompson 1982, Stevenson and Thompson 1985), but little information is available for broadleaves. Cloches improve the microenvironment for growth. Air temperatures up to 20°C above ambient have been recorded inside clear polythene cloches, but increases of 8-16°C are more usual (Thompson and Biggin 1980, Mason 1994). Minimum temperatures are usually only about 1-2°C above ambient levels. CO_2 produced by soil organisms and plants accumulates under cloches (Shadbolt et al. 1962), which may also stimulate seedling growth (Rey and Jarvis 1998, Kellomäki and Wang 2001). Because moisture is retained within the cloche system, downward leaching of nutrients is reduced when non-perforated cloches are used (Thompson and Biggin 1980), but is unclear how effective perforated covers and floating mulches are in doing this.

The main aim of this study was to evaluate the effects of three different cloche types and a floating mulch on the germination and growth of common birch seedlings after sowing in March, April and June (delayed from May) in the nursery.

Materials and methods

The nursery, seed material and sowing

The seedlings in this study were grown at the Coillte Ballintemple Nursery, Co Carlow (52° 44′ N 6° 42′ W, 100 m). The soil at Ballintemple is a sandy loam of pH 6.5, having an organic matter of ca. 5%, and sand, silt and clay fractions of 66, 19, and 15%, respectively. The soil was sterilised in August 2001 using Metham Sodium (a.i. sodium N-methyl dithiocarbamate) at 800 l/ha and the beds were formed three weeks later. The seeds from a single lot (seed zone details: BC-IELAOI-A19, Templetouhy Co Laois) were chilled in excess water for 3-6 weeks. After seed pre-treatment there were about 558,000 germinable seeds kg^{-1}. The sowing rate was about 680 bed m kg^{-1} to achieve a target seedling density of about 175 plants m^{-2}. The seeds were covered with 3-5 mm of lime free grit (1 m^3 100 m^{-2}) just after sowing. The seeds were sown on 25th March, 13th April and 5th June 2002. The last sowing date was later than scheduled (mid May) due to adverse weather conditions.

Seed germination and seedling density at end of season

Treatments and experimental design

The experiment was laid down as a randomised split-plot design. The trial contained nine nursery beds, each about 200 m long. Three randomly chosen beds (main plots) were sown in March, April and June. Soon after sowing, four different bed covers (subplots) were erected/ laid over the seedbeds; including a spun bonded polyester fabric (F), a non-perforated (N), a perforated (P) clear polythene type cloches and a photodegradable polythene floating mulch. Each subplot was 20 m long. Therefore, there were a total of three main plots (sow dates), each containing nine split subplots (seedbed covers). The non-perforated cloche (British Polythene Industries) was 65 µm thick; the perforated polythene cloche (Sotrafa, Spain) was 35 µm and had 10 mm diameter perforations, with 200 perforations per m^2; the fleece gauge was 17 g m^{-2} (Agryl P17, Agriweb, France). The mulch was a 6-µm thick photodegradable maize plastic (IP Europe, France). No other information is available for these covers.

Observations

The number of germinating seeds was recorded at two sampling points (each 0.0625 m^2) in each subplot at 4-7 day intervals soon after germination commenced. These points were located near the centre of each subplot, approximately equidistant from each other. Total germination per subplot and mean germination time (MGT) was calculated from these data. Mean germination time was calculated as the mean number of days since sowing for seeds to germinate in each subplot (Jones and Gosling 1994).

The number of seedlings in two sampling points (each 0.50 m^2) in each subplot was recorded at the autumn 2002. These points were located at random in the centre of each subplot.

Data analyses

The effects of sow date and bed cover type on parameter responses were analysed according to a split-plot factorial design. The germination counts were transformed to log values to standardise variation. Treatment means were compared using least significant difference tests.

End-of-season morphology

In general, the growth of seedlings derived from seeds sown in June and under the floating mulch was very poor, so seedlings from these plots were excluded from this part of the experiment; temperature data also are not presented for this cover type.

Treatments and experimental design

The cloches were removed at different times for practical reasons. The N cloche was removed early in the season (25 June) as the soil tended to get too dry under it. In the other two treatments, the cloches were removed when the leading shoots began to touch the surface of the cloche, which was about two weeks later for the F cloche (8 July) and another month later for the P cloche (8 August).

Sampling, observations and measurements

Seedlings were lifted from each subplot in February 2003 to examine the effects of treatments on morphological quality. About 150 seedlings were lifted from each subplot, 50 from each of three randomly chosen positions located in the centre of each subplot. Each batch of 50 plants was bundled separately. The plants were then dispatched to UCD and held at 2-4°C until the time of processing. The diameter and height of 10 plants sampled at random from each bundle was measured, after which the roots of the plants were washed, excised at the root collar and then placed in an oven at 105°C for 24 h. The weights of the shoot and root of each plant were measured after drying. The shoot to root dry weight ratio, and the proportion of 'target' seedlings (>40 cm tall and 4 mm diameter) per subplot were calculated from these data.

Analyses

The effects of treatments were analysed according to a split-plot factorial design to test for the effects of sow date and cloche type. Proportion data were transformed to arcsine square root values before analysis. Treatment means were compared using least significant difference tests.

Temperature data

Temperatures were recorded at the bed surface at only one location under each cover type from early April onward, and at the same location thereafter until October after the covers had been removed. Temperatures were recorded (TinyTag®, Gemini Data Loggers, Monotherm Ltd., Dublin) at approximately 5-minute intervals, but less frequent readings were recorded on some dates. Unfortunately, the data are not available for all periods due to instrument malfunction. Mean, maximum and minimum temperatures were determined from these data.

Results

Seed germination

Sowing date significantly (both $p<0.0001$) influenced total germination (Table 1), but bed cover type or its interaction with sow date had no significant effect. There were 1,380 germinants per m^2 in the plots sown in March, significantly ($p<0.0001$) more than the 635 and 1,095 for those sown April and June, respectively. Both sowing date ($p<0.0001$) and seedbed cover ($p<0.05$) significantly influenced speed of germination. Seeds sown in June germinated after only 43 days compared with 61

Table 1. *Mean germination, mean germination time – MGT (days since sowing and mean date) and mean number of seedlings that survived until the autumn in 2002. Values in parentheses are standard errors.*

Sow date	***Germination***	***MGT***		***Number of seedlings***
	number m^{-2}	***Days***	***Date***	***m^{-2}***
March	*1,380 (218.4)*	*88 (0.72)*	*21 June*	*166 (15.5)*
April	*635 (77.0)*	*61 (0.77)*	*13 June*	*88 (10.6)*
June	*1,095 (79.1)*	*43 (0.53)*	*18 July*	*95 (8.5)*

and 88 days for those sown on earlier dates. The corresponding mean dates of germination are 21 June, 13 June and 18 July for seeds sown in March, April and June, respectively. On average, seeds germinated a little more quickly under the N and P cloches and the mulch (about 63 days) than under the F cloche (66 days).

There were significantly ($p<0.05$) more seedlings in the autumn in beds sown in March (166 seedlings per m^2) compared with beds sown later (88 and 95 for the March- and June-sown beds, respectively) (Table 1). Bed cover or its interaction with sow date had no significant effect on these values.

End-of-season morphology

Morphological attributes

The effect of sow date or its interaction with cloche was not significant for any morphological parameter except height/ diameter ratio or sturdiness ($p<0.05$). Nevertheless, the means are presented for each sow date and cloche type (Figure 1). Cloche type significantly affected height, shoot dry weight and the proportion of plants that reached target size. Cloche type had no significant on the other parameters.

Seedlings grown under the N and P cloches were significantly ($p<0.05$) taller than those grown under the F cloche, although differences were not entirely consistent with sow date. For the March sow date, the mean heights were 41, 40 and 34 cm for seedlings grown under the N, P and F cloches, respectively. The equivalent values for the April sow date were 34, 38 and 34 cm. Similar differences were evident for the dry weight measurements. Sturdiness (low values indicate more sturdy plants) or height/diameter ratio was influenced by cloche type for seedlings derived from seeds sown in March, but not for those sown in April, especially for seedlings grown under the N cloche. Seedlings that were grown under the N cloche derived from seeds sown in March were less sturdy (10.4) than those from the other treatment (7.5-9.5) plots.

Cloche type had the most dramatic effect on the proportion of plants that reached target size dimensions (>40 cm tall and 4 mm diameter) (Figure 1). Significantly ($p<0.05$) fewer seedlings reached target dimensions under the F cloche than under the N and P cloches. For the March sow date, 16, 44 and 53% of the plants reached target size under the N, P and F cloches, respectively. The equivalent values for the April sow date were 35, 38 and 46%.

Effects on temperature

Temperatures were warmest under the non-perforated cloches and coolest under the fleece cloche when compared with the uncovered bed. For example, the mean temperature during late June was 22.3°C under the N cloche, 19.8°C under the P cloche and 17.0°C under the F cloche (uncovered, 16.9°C). Average maximum temperatures were 35.5, 34.8 and 28°C (uncovered, 26.8°C) and average minimum temperatures were 12.8, 10.3 and 9.0°C (uncovered, 7.9°C) under the P, N and F cloches, respectively. The absolute maximum temperature recorded during this period was 37, 41.5, and 34.3°C under the P, N and F cloches, respectively (uncovered, 30.6°C).

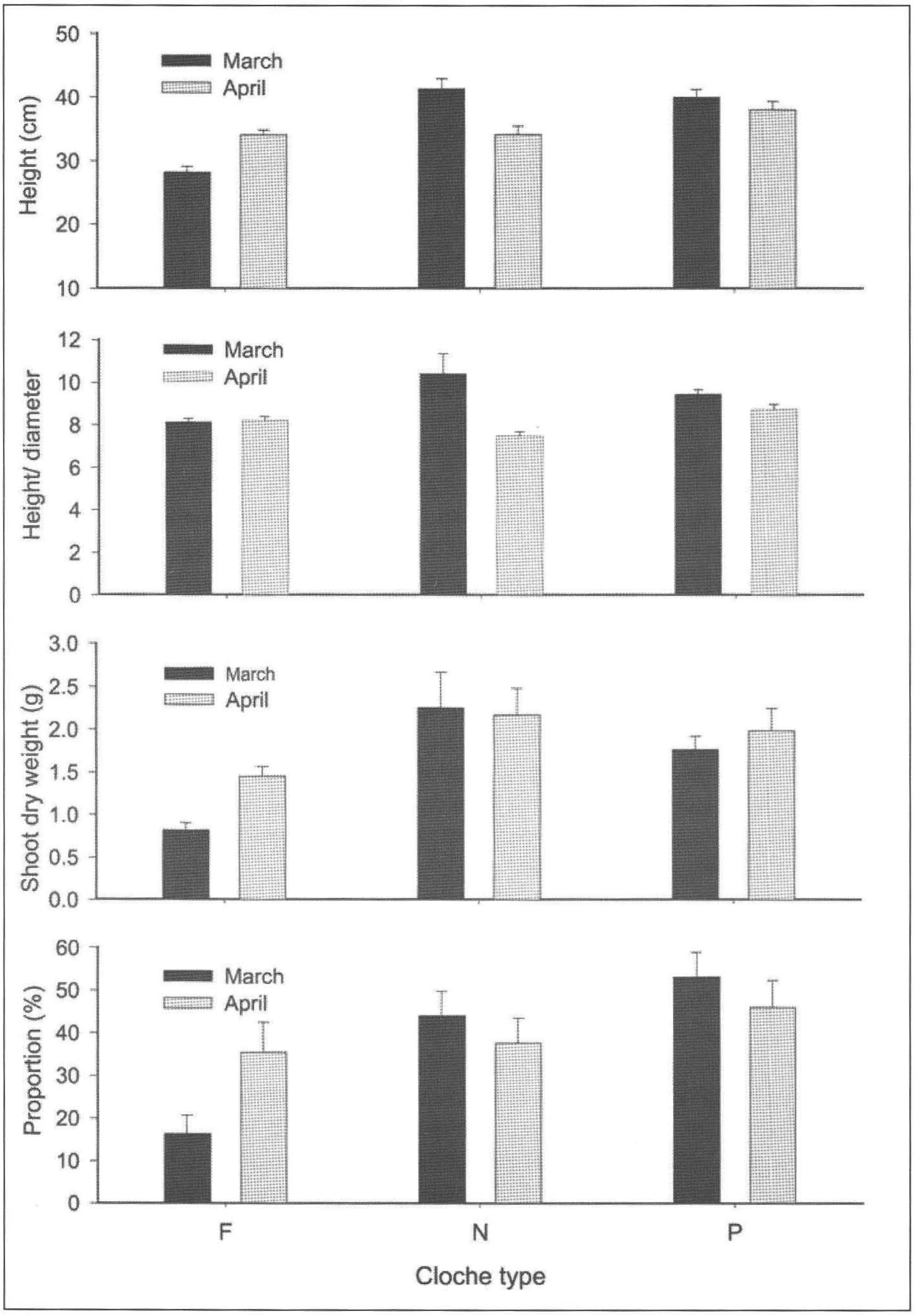

__Figure 1.__ The effect of cloche type and sow date on height, height/ diameter ratio, shoot dry weight and proportion reaching target size dimensions (>40 cm tall and 4 mm diameter) in birch seedlings in the nursery in 2002. Cloche types: F, fleece; N, non-perforated polythene; and P, perforated polythene. Vertical lines are standard errors.

Discussion

Seedbed cover type had no consistent effect on germination (and the effect on mean germination time was small) in this study, suggesting that all provided favourable conditions for germination. However, germination was better for seeds sown in March than for those sown on other dates, but the exact reason for this is unclear. The March-sown seeds may have benefited from a longer warm-up period. Although the seeds were pretreated, dormancy may not have been fully released at the time of sowing. Birch seeds are sensitive to chilling temperatures, and temperatures after sowing in March might have been more favourable for breaking dormancy (DeAtrip and O'Reilly 2005). While more seeds germinated after sowing in March than in April, the mean date of germination was later for the former than the latter sowing date (Table 1). While it is likely that environmental conditions favoured seed dormancy release after sowing in March, subsequent progression to germination might have been slow, thus increasing the mean germination time. The seeds sown in June also germinated well, perhaps because they received additional chilling during pre-treatment (sowing was delayed by about 3 weeks). Other environmental conditions (e.g. moisture availability) just after sowing in March may also have favoured germination. Warm temperatures improve the germination, survival and growth of birch (Thompson and Naeem 1996). Cultural factors may also have contributed to these differences. Although great care was taken during all sowing operations, it is impossible to be certain that the method was identical on each date.

Bed cover type had no significant effect on the density of seedlings in the beds at the end of the season, suggesting that plant survival was not affected. As expected, the March-sown bed had the most plants at the end of the season, in agreement with the trend for germination. However, only about 9-12% of the seeds that germinated survived until the autumn (Table 1). Seedbed densities at the end of the season (88-166 plants) were not any higher than might be expected had cloches not been used (target of 175 plants). Thompson and Biggin (1980) found that lodgepole pine (*Pinus contorta* Dougl) survived better under clear polythene cloches than in uncovered (control) beds.

Although the germination data may have exaggerated actual germination, errors of this kind would have been consistent across treatments. The germination data were based on subplots of 0.0625 m^2, compared with 0.50 m^2 used for the autumn counts. If the germination subplots were slightly larger than intended due to errors in demarcating the boundaries, this would magnify differences when converted to values per m^{-2}. Furthermore, the method used to estimate seed germination may have contributed to this outcome. Germinants were counted when they reached the cotyledon stage; the tip of each stem was excised near the bed surface to facilitate this process. More seeds than otherwise might then have germinated, presumably because the topped plants could compete less effectively for available resources, thus perhaps inflating germination values. Nevertheless, it is well recognised that the average yield of plants is low in birch in Irish (data on file) and British (Mason 1994) nurseries, although little information is available on the effect of cloches on yields.

Seedbed density had no significant effect on morphological quality, perhaps because none of the densities at the end of the season exceeded the recommended target (175 m^{-2}). High seedling densities lead to competition for water, nutrients and light, thus reducing plant quality (Mason 1994). In particular, about 50% of the seedlings reached target dimensions under the P cloche, suggesting that the use of this cloche type might be economically viable in the nursery. Birch seedlings grown in Ireland without the aid of cloches are normally only about 10 cm tall at the end of the first growing season (data on file). Although not statistically significant, the results suggest that these values might be less influenced by sowing date for seedlings grown under the N and P cloches than under the F cloche. While the plants reached target planting stock dimensions, they were a little less sturdy (mean ranged from 8-10) than recommended for use in Britain (6-7.5) (Aldhous 1994). Nevertheless, the shoot: root ratio was <3 and the root growth potential of the seedling was excellent (data not shown), regardless of treatment, suggesting that the seedlings were fit for planting in the forest. The benefits of using cloches to improve the growth of several conifer species have been documented previously (Thompson and Biggin 1980, Thompson 1982).

High temperatures under cloches are rarely deleterious for tree growth if high humidity (ca. 95%) levels can be maintained (Kaneski 1968), but only the non-perforated cloche used in this study could potentially maintain very high humidity levels (humidity levels were not monitored). The edges of the cloches were secured with sandbags in this study, which may not be fully effective in sealing the N cloche. For this reason, the N cloche had to be removed earlier than planned because the soil underneath it was getting too dry. Wind damage greatly exacerbated the problem. Ballintemple Nursery is relatively exposed, perhaps making this type of cloche unsuitable for use there. Thompson and Biggin (1980) found that sealed cloches (edges buried in soil) slightly increased the growth of lodgepole pine seedlings, but nearly 20% of the seedlings died under unsealed cloches compared to only 2% under the sealed cloches. A tight seal must be maintained under this type of cloche to retain all the moisture since very little rainfall can enter the system. Sealed non-perforated cloches can maintain adequate soil moisture levels because water vapour produced by evapo-transpiration condenses on the polythene surface and is returned to the soil (Thompson and Biggin 1980). Despite the shorter period of cover, seedlings in this study grew better under the N cloche than under the F cloche.

The growth of seedlings under the perforated cloche was good in this study, suggesting that this cloche type might be preferable to the non-perforated type (since the soil under it is less prone to drying). It is likely that the cloche provided shelter, thus reducing wind and evapo-transpiration and raising temperatures, resulting in better seedling growth.

The results of this study showed that it is possible to produce birch seedlings of planting stock size under cloches in a single growing season. However, some caution is advised. The results reported are for one year only (although it might be considered an average or below average growing season) so the response might differ in other years. The data reported are for seedlings sampled from the centre of the beds; these values might overestimate the growth and yield data for the whole bed.

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