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162. Lifting and handling stresses can cause shoot dieback in oak. O'Reilly, C. and Cabral, R. COFOR Connects, Reproductive Material No. 14. 4 p. 2008.

- *The stresses of lifting, handling and storing pedunculate oak (Quercus robur L.) and sessile oak (Quercus petraea (Matt.) Liebl) seedlings before planting rarely causes mortality after planting, but shoot dieback is a more common response.*
- *Oak seedlings should be lifted in the nursery from about November to March, when they are most resistant to these stresses.*
- *Readiness for lifting can be assessed objectively using shoot tip dry weight fraction (DWF), which is the dry weight relative to the amount of water the shoot can hold.*
- *Seedlings can be safely lifted when DWF ≥0.42, and values should not decline to <0.40 before planting. Root electrolyte leakage (REL) and root DWF (same values as for the shoot tips) can be used to augment this information.*
- *REL should not exceed 25% in pedunculate oak and 30% in sessile oak.*

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Lifting and handling stresses can cause shoot dieback in oak

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Introduction

Pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl) are an important component of the broadleaf planting programme in Ireland. About 2.5 million oak seedlings were planted in 2006. Both oak species are considered relatively easy to establish, and handling and storage stresses rarely cause mortality after planting. However, this perception may be misleading since the species has a well developed stem dieback stress-response mechanism. Pre-planting stresses may be a major cause of stem dieback after planting in oak. Dieback frequently leads to the development of a crooked and malformed stem (Figure 1). This may lead to the need to carry out expensive formative pruning after planting.

If the guidelines recommended in this note are followed, it is likely that the incidence of stem dieback after planting can be reduced. However, adverse post-planting conditions may cause considerable shoot dieback in oak for many other reasons. Dieback can be expected if seedlings are planted on unsuitable (e.g.

Figure 1. The quality of the shoot system in oak seedlings, from good (straight, single leader) to poor (crooked leader, "stag headed" appearance) to very poor (leader has died).

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exposed) sites, even if they had been carefully handled and stored before planting

The annual cycle of dormancy and stress resistance and the impact of storage stresses on the quality and field performance of seedlings of both oak species were studied in a series of experiments conducted by UCD and Coillte (funded by COFORD, Coillte and the EU FAIR programme). Some of the key findings from these studies (Cabral and O'Reilly 2005; Cabral 2007), especially as they pertain to operational forestry in Ireland, are summarised in this note. Most of the information presented is based on the results for pedunculate oak. Both species are similar, but peduculate oak tends to become more deeply dormant than sessile oak.

Dormancy and stress resistance levels

The annual cycle of dormancy development and release is clearly defined in oak, as in most other broadleaf species. The resistance of seedlings to the stresses of handling and storage changes during the dormancy period. Dormancy and stress resistance develop rapidly as the leaves begin to fall in the autumn (which commences in October most years) and they are usually sufficiently stress resistant for handling and storage about one month later. Stress resistance remains high thereafter until early to mid March each year, about 2-3 weeks before the buds flush. It is preferable to determine the exact level of stress resistance, rather than relying solely on calendar date as a guide. Fortunately, there is an objective method of assessing readiness for lifting, as described in the next section.

Estimating dormancy or stress resistance status

Oak seedlings accumulate food reserves in preparation for winter, especially in the taproot and shoot tip tissues. A large proportion (>50%) of the nutrients that are stored at this time would have originated from the resorbtion of nutrients from foliage before senescence. This results in an increase in dry matter in these tissues. Concomitantly, the amount of water that the cells can hold declines. This appears to be part of the process of hardening off; less water is available to freeze and the higher concentrations of ions and other solutes in the cells greatly decrease the freezing point (and acts like antifreeze). Therefore, the dormancy status of seedlings can be estimated using dry weight fraction (DWF), which is the dry weight relative to the maximum amount of water a specific tissue sample can hold. DWF can be assessed in less than 24 hours. Shoot tip DWF can also be used to assess plant quality before planting (as described separately below).

Field performance and dry weight fraction

The quality of the shoot system (proportion with good quality stems) of seedlings planted in a field trial at Kilmacurra, Co Wicklow, in 1997/98 is shown in Figure 2. The seedlings were carefully handled and planted within 2-3 days of lifting (but under operational conditions seedlings may be stored for much longer than this).

The annual cycle of shoot tip DWF in 1997/98 is shown in Figure 3. This is a typical pattern with DWF increasing rapidly from September onwards, reaching a maximum in early December. DWF remains high until early March, but then declines rapidly as the buds resume activity in the spring. Although shoot quality (Figure 2) was good for seedlings planted when DWF exceeded 0.40 (Figure 3), lifting operations should proceed only when DWF is ≥0.42 (from late November to early March) for reasons outlined below.

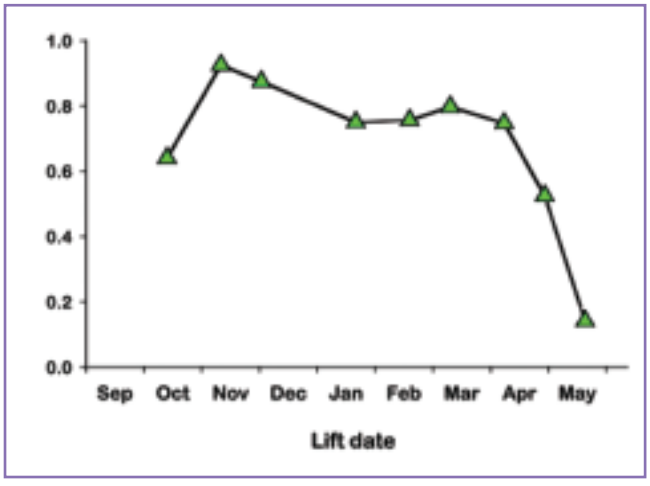

Figure 2. The effect of lift date on shoot quality after planting in oak seedlings at Kilmacurra in 1997/8. Note that the seedlings were lifted and handled carefully and planted within three days, so the planting window may be narrower under operational conditions.

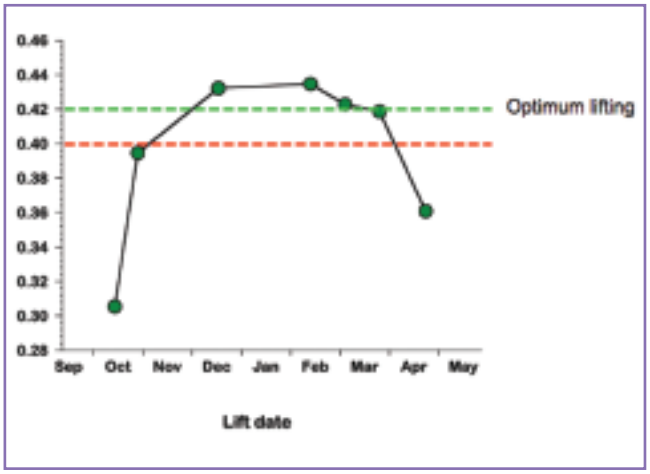

Figure 3. The effect of lift date on shoot tip dry weight fraction in oak seedlings at Kilmacurra in 1997/98. Seedlings can be safely lifted when values ≥0.42 (green line) and dieback can be expected to increase when values decline below about 0.40 (red line).

Although less useful for determining safe lifting 'windows', root electrolyte leakage (REL) may provide additional information on the physiological status of oak seedlings. REL varies seasonally (Figure 4). Lifting can commence once REL is lower than about <25% in pedunculate oak (which is October to April in the example below, Figure 4) and 30% in sessile oak, but DWF is probably the most reliable indicator of plant readiness for lifting/storage.

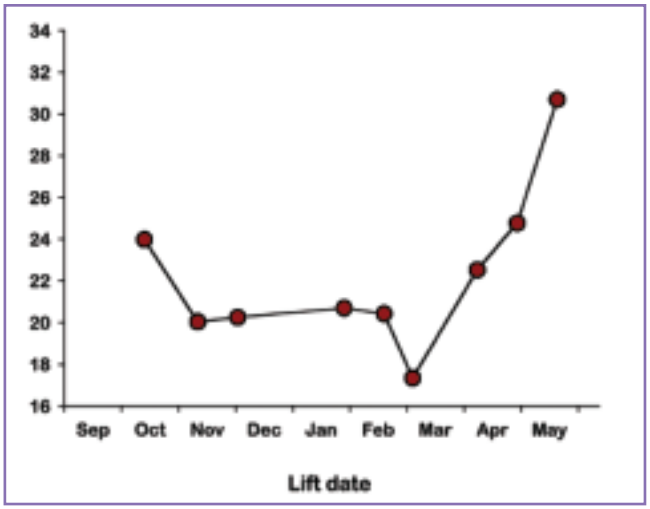

Figure 4. Typical seasonal pattern of change in root electrolyte leakage in oak seedlings.

Plant handling and storage

The logistics of nursery and planting operations dictate that seedlings are stored for some time before planting. In particular, seedlings may have to be cold or freezer stored for weeks or months prior to planting. Cold storage facilitates both nursery and field planting operations. Seedlings can be maintained in a dormant state and then planted when conditions are favourable. Oak seedlings store well at cold or freezing temperatures if lifted once shoot tip DWF≥0.42. This generally coincides with the late November to early March period, as recommended for the lifting of stock for immediate planting.

Monitoring seedling quality after lifting

Seedlings are often stored for short periods at ambient temperatures before planting, at the nursery, during transit, at sorting depots and at the planting site. The potential for deterioration during these periods is high. Plant quality declines mainly due to root desiccation (e.g. holes in storage bags) and the depletion of food reserves.

Since the tissue in the shoot tip responds quickly to stress, leading to stem dieback if the stress is severe enough, DWF is a useful measure of physiological quality in oak (Cabral and O'Reilly 2005). The results of experiments at UCD on the effect of simulated ambient storage before planting confirmed this (Figure 5). Seedlings that had a DWF <0.40

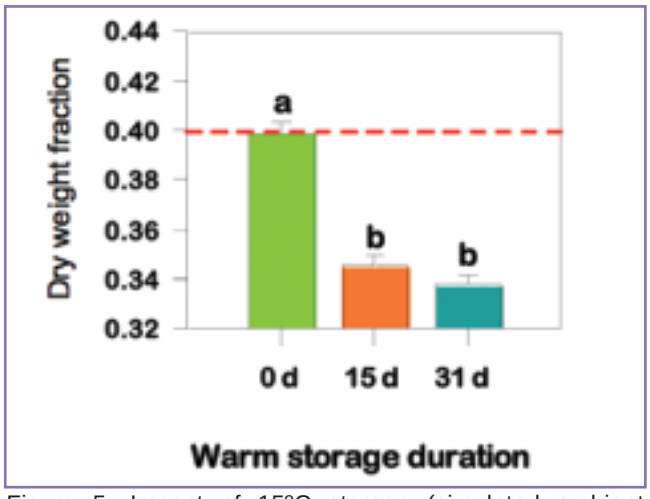

Figure 5. Impact of 15ºC storage (simulated ambient storage) on shoot tip dry weight fraction in oak seedlings. Shoot dieback can be expected when values decline below 0.40.

before planting generally performed poorly. The benchmark for lifting seedlings in the nursery (0.42) is higher than that recommended for stock at time of planting, the additional 0.02 providing a 'cushion' to allow for a small decline in DWF after lifting. DWF can be expected to decline during handling and storage since the plants will consume food reserves during this period.

Although the DWF of the shoot may provide adequate information on the physiological quality of oak seedlings, it may not provide sufficient information in all cases. The DWF of the taproot (which should also exceed 0.40) may be used to supplement this information. In addition, root electrolyte leakage (REL) values should be determined, especially if desiccation stress is suspected. A few hours of desiccation may cause root damage, but this stress might not be reflected in the DWF reading. REL >25% in pedunculate oak and >30% in sessile oak may indicate that the roots have been damaged (as for freshly lifted stock). However, REL alone does not provide sufficient information on the quality of oak stock.

Conclusions and recommendations

- Oak seedlings can be safely lifted and stored when the dry weight fraction of the shoot tips is greater than 0.42, corresponding with the late November to early March period (but the exact date may vary from year to year).
- DWF of the shoot tips should not decline below 0.40 before planting.
- The DWF of the tap root (same benchmark values as for shoot tips) can be used to augment this information.
- Fine root electrolyte leakage provides additional information. REL should not be higher than 25% in pedunculate oak and 30% at the time of lifting or planting.

References

Cabral, R. 2007. *Physiological responses of pedunculate oak and Douglas fir seedlings to the stresses of handling and storage.* PhD Thesis, University College Dublin.

Cabral, R. and O'Reilly, C. 2005. The physiological responses of oak seedlings to warm storage. *Can. J. For. Res*. 35: 2413-2422.