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Testing Plant Quality

INFORMATION NOTE
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SUMMARY

Successful tree establishment by planting requires good quality plants. Plants of good quality are better able to withstand transplanting shock and difficult post-planting conditions; this resilience leads to increased survival rates, faster early growth and reduced establishment costs. Use of poor quality plants will result in low survival and little height growth in initial years. A number of tests are described which can distinguish between plants of good and poor quality and indicate their potential to survive and grow after planting.

INTRODUCTION

1. Successful establishment of trees depends upon a wide range of interacting factors including climate, soil, competing vegetation, pests and plant characteristics. The likelihood of successful establishment can be improved by appropriate cultivation, drainage, weed control, protection and correct species choice. One aspect that is increasingly recognised as contributing to good establishment is planting stock quality.

2. Over the past 10 years, plant quality testing has developed from a research project, seeking to detect cold storage and other forms of damage to plants, to a set of techniques to assess the quality of forest nursery stock. This Note describes the range of techniques that can be used by nursery and forest managers to assess stock quality and considers their practical implications.

OUTLINE OF PLANT QUALITY TESTING TECHNIQUES

3. There are several morphological and physiological assessments that measure different aspects of plant condition (Table 1).

Morphological tests include:

- assessing height and root collar diameter (RCD) (compared with an industry standard BS 3936 part 4 (BSI, 1984));
- visual damage and form assessment;
- root:shoot dry weight ratio.

Physiological tests include:

- root electrolyte leakage (REL) (McKay, 1991 & 92);
- shoot electrolyte leakage (SEL) (following McKay, 1992);
- root moisture content (RMC) (Tabbush, 1987);
- root growth potential (RGP) (Tabbush, 1988).

Table 1 Tests available to assess plant quality: type of assessment and length of time in working days required from receipt of plants to posting results

Test type		Physical		Physiological		Duration of test (lapse time)
		Shoots	Roots	Shoots	Roots	
Morphology	Height, RCD, usability	✓	✓	-	-	<1
	Root:shoot ratio	✓	✓	-	-	4
Root electrolyte leakage		-	-	-	✓	2
Shoot electrolyte leakage		-	-	✓	-	2
Root moisture content		-	-	-	✓	4
Root growth potential		✓	✓	✓	✓	16

Physiological tests can give an indication of tree dormancy status pre-lifting, or after storage, and can detect plant damage due to desiccation, rough handling, overheating or freezing.

EFFECT OF PHYSIOLOGICAL CONDITION ON PLANT ESTABLISHMENT

4. Using good quality planting stock is an essential precondition for successful establishment. Planting poor quality stock may result in reduced survival and early growth. For example, Figure 1 shows a decrease in second year survival of Sitka spruce with increasing REL value. These data are taken from an operational trial of plant quality testing in which plants were delivered to the planting site from cold storage on four separate occasions during the planting season. Plants with REL values above threshold value (25%) have significantly lower survival rates than plants below the threshold. Plants with high REL values also have lower height increments than plants with acceptable values (Table 2). The threshold levels are supported by numerous experimental data using a range of species (e.g. Douglas fir, Scots pine, larches).

Table 2

Effect of REL on Sitka spruce tree height increment one year after planting

Delivery	Root electrolyte leakage value (%)	Height increment (cm)
1	21.2	1.90
2	20.0	2.47
3	24.3	-0.37
4	26.4	-3.40

PHYSIOLOGICAL AND MORPHOLOGICAL INDEXES OF PLANT QUALITY

5. Two different aspects of biomass allocation can be measured: height and root collar diameter and the ratio of root to shoot dry weights. Height and root collar diameter of a ten tree sample are compared against BS3936 part 4; those exceeding the minimum

Figure 1

REL and second year survival of Sitka spruce (Queen Charlotte Islands origin) 1u1 planting stock. Plants were lifted, cold stored for various intervals and dipped before planting

root collar diameter for a specific height class are acceptable. Plants with large fibrous root systems are better able to withstand transplanting and usually grow better in the year following planting than stock with poor root:shoot ratios. A low ratio may indicate plants with roots that will be inadequate to supply sufficient water to shoots in stressful conditions.

6. A simple usability assessment can also be carried out. Physical injury or damage to roots and shoots such as frost damage, needle discoloration, broken and double leaders, torn or waterlogged roots is recorded. Damaged plants are unacceptable and should be culled out at the nursery (BSI, 1984). Plants with 'J' rooting, where the tap root angle is greater than 45° from the vertical without compensating fine root structure, are also classed as unacceptable.

7. REL values are highly correlated with plant survival and height growth (e.g. McKay, 1994). Plants that are actively growing or have damaged roots have higher REL values than dormant or undamaged plants. Low leakage rates are associated with high plant survival and REL is the most reliable index of potential performance found so far. Baseline information is now available for a range of species (Table 3).

8. SEL is determined using the same test procedure as REL to measure electrolyte leakage from needles and shoots and can detect damage from overheating, frosting or deterioration during storage. SEL can be used to predict if needle loss after planting is likely.

9. RMC is the weight of water contained in the fine roots expressed as a percentage of fine root dry weight. Once roots have been dried below a certain value they are irreparably damaged and will not recover with rewetting. Damaged plants are less likely to survive, even when planted into less stressful conditions. Critical values for RMC have been determined by experimentation (Tabbush 1987; McKay and White, 1997).

10. RGP is a slower and more expensive test of plant physiology than REL. RGP is a measure of the ability of a plant to produce new roots under favourable growing conditions, and can be used to determine plant vitality and dormancy (Tabbush, 1988). It has been used to assess potential performance but in Forest Research's Plant Quality Testing Service it is mainly used to detect damage which becomes apparent when plants begin to grow, e.g. frost and pesticide damage.

11. A combination of tests is most appropriate when dealing with large batches of plants. An initial sample of plants should be examined using both morphological and physiological tests to obtain a full description of plant quality. Thereafter REL testing alone will provide sufficient information on condition of samples from the same batch.

Table 3 Baseline REL values expected for major species when dormant

Species	Baseline when fully dormant (%)	Maximum acceptable REL (%) values for different plant types		
		Bare-root transplant	Bare-root undercut	Cell-grown stock
Pines	10–15	20	25	30
Norway spruce	10–15	25	25	30
Sitka spruce (QSS, VPSS)	10–15	25	25	30
Sitka spruce (RSS, WSS)	15–20	30	30	35
Douglas fir	15–20	30	30	35
Larches	10–15	25	30	35
Noble fir, Grand fir	15–20	20	30	35
Ash	5–10	25	25	30
Rowan, oak, beech, lime	10–20	30	30	35
Birch, cherry, Norway maple	20–30	35	35	40

QSS = Queen Charlotte Islands origin, VPSS = genetically improved material; RSS = Oregon origin, WSS = Washington origin.

PRACTICAL IMPLICATIONS

12. Experience over the last few seasons has shown that REL testing on its own is the most useful predictor for forest managers. The value of testing is now recognised by the forest industry and wider use of the service should mean the best quality plants are used. This in turn should lead to better survival and early growth of trees.

13. REL tests can also be used to measure the plant's dormancy status; the nursery manager can use this information to schedule nursery operations since plants are least likely to be damaged by lifting, cold storage and handling when they are fully dormant. Most species can be safely cold stored for up to 3 months when lifted in a dormant state, and their condition during storage can be monitored using REL to ensure no deterioration has occurred.

14. The threshold REL value for Sitka spruce for ≥90% survival is 25% (Table 3); values above this threshold indicate that physiological damage has occurred or the plants are not fully dormant. Most Sitka spruce tested at NRS have been below this threshold (e.g. season 1995/96 Figure 2).

CURRENT AND FUTURE DEVELOPMENTS

15. A prototype Plant Quality Testing Service (PQTS) was first offered by the Forestry Commission during the 1992/93 planting season to check on the practical utility of physiological testing. The service tests a wide range of forest seedlings and provides reports giving information on their condition and potential survival and growth for anyone in the forest industry and, more recently, for those in the amenity sectors.

16. Interpretation of results takes into consideration physiological values, plant morphology, overall condition, plant type and planting date. Expected survival values are derived from experiments established on a range of upland site types, including areas where soil water deficits can be high and spring droughts common (Table 4). Under these conditions lower quality plants become desiccated and can die. Good quality Sitka spruce can be more tolerant to spring drought compared with other species. This is reflected in the range of expected survival values, where other species may suffer greater losses on extreme moisture stressed sites than equivalent quality Sitka spruce. Improved survival can be expected on sites less prone to spring drought (McKay and White, 1997). Quality categories also assume planting on a well-cultivated, weed free site, where plants are protected from insect and browsing damage.

Table 4

Quality category and expected survival percentage for Sitka spruce and other species on a range of site types

Quality category	Expected survival for Sitka spruce	Expected survival for other species
Good	90–100%	80–100%
Marginal	70–90%	60–80%
Poor	Less than 70%	Less than 60%

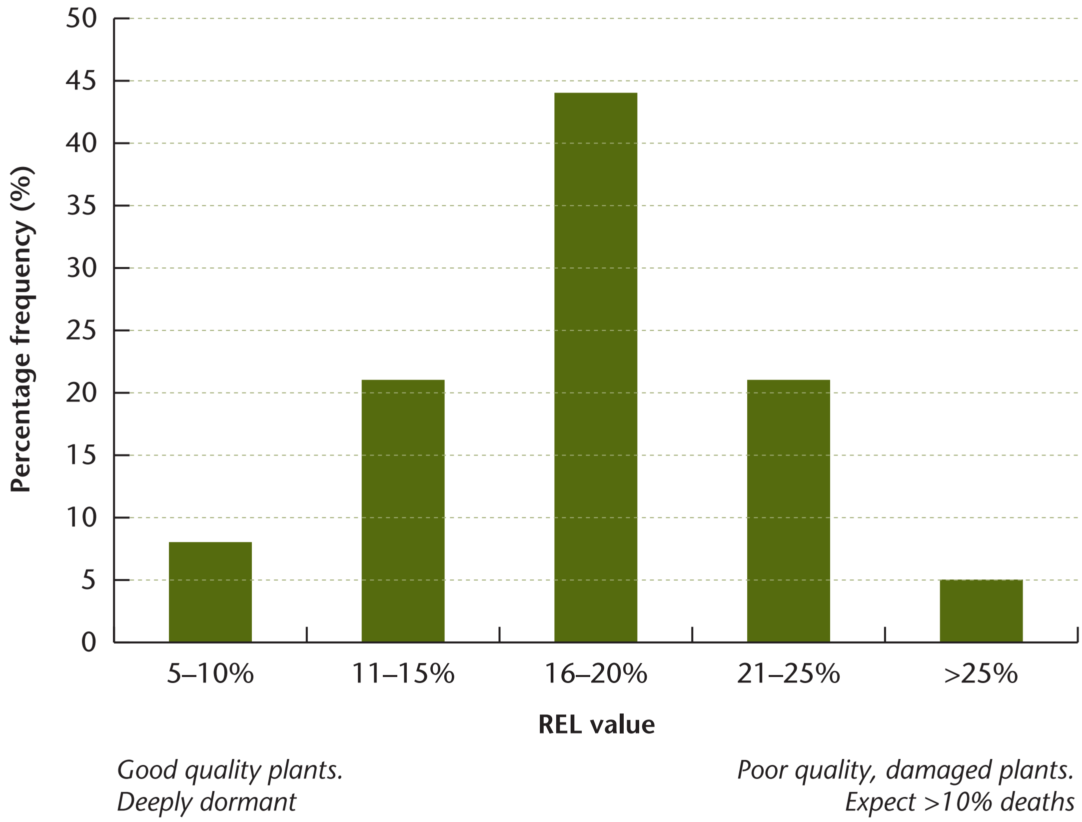
17. The majority of REL reports are faxed to customers at the end of 2 working days from receipt of plants for testing. Exceptions are when plants arrive on Thursday afternoon or Fridays when plants are retained in cold storage until the beginning of the next working week. Root moisture content adds an additional 1–2 days. Full tests take 4 working days from receipt of plants to the production of a full report, although REL results are often faxed in advance of the full report if requested. Root growth potential measurements take 14 days for most conifer species.

18. Several nurseries now have facilities for REL testing of plants prior to dispatch and Forest Research continues to offer an independent Plant Quality Testing Service. Use of the techniques described in this Information Note will give greater assurance of plant quality and so contribute to better establishment.

19. Over the period from 1992/93 to 1996/97 approximately 1500 samples have been tested using the service. Further information on the testing service and/or advice on installing test facilities can be obtained by contacting either the author or Dr Helen McKay at the address on page 6.

Figure 2

Root electrolyte leakage rates for all Sitka spruce plants tested during 1995/96



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