A Tube Method for Grafting Small Diameter Scions of the Hardwoods *Quercus*, *Fraxinus*, *Betula*, and *Sorbus* in Summer

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In conventional grafting of oak and ash in February, the graft viability over 3 years was 15% and 97%, respectively, with 64% of oak clones responding and 100% of ash, using scions from mature trees. Using single node scions from these grafted plants, epicormic shoots, crown shoots, and a silicone tube to hold graft unions we recorded improved rates of graft viability by summer grafting. All oak and ash clones made viable grafts with efficiencies of 18% to 100%. Summer grafting of hardwoods allows several serial grafts per year and potential to rejuvenate tissues.

INTRODUCTION

Vegetative propagation of mature trees is generally difficult but it is an essential step in a programme for genetic improvement of trees such as oak and ash. Conventional grafting is usually performed once a year in the early spring (February to March) and uses 2-year-old rootstocks, elastic tying of the graft union, and waxing of the plant.

Grafting of mature scions to a seedling rootstock (primary graft) followed by re-grafting of growths from these primary grafts, with subsequent repeated re-grafting of new growths, several times, may be a way of rejuvenating material which originally came from mature trees (Huang et al., 1992; Franclet, 1983).

This study reports on results from conventional grafting as well as a new tube method, which can be applied to oak, ash, birch, and sorbus for grafting thin-stemmed scions to seedling rootstocks in summer and winter.

MATERIALS AND METHODS

Scionwood was collected from selected trees in mature forests, stored as branches at 1C for between 3 and 30 days in February to March, until grafted onto 2-year-old rootstocks. A splice (whip) graft was made using multi-budded scions, tied with elastic bands, and the union plus scion painted with molten paraffin wax.

Tube grafting was carried out using 4-month-old to 8-month-old rootstocks of, mainly, *Q. robur*. Scions were collected from 2-year-old, conventionally grafted, plants except where otherwise stated. A diagonal cut at an angle of approximately 50° was made with a scalpel in the stock and scion.

Laboratory silicone tubing (internal diameter 3.2 mm, wall thickness 1.6 mm) was cut into lengths of 2 to 3 cm and first placed halfway over the stock. A caliper

(Mututoyo, Japan) was used to determine the stem and stock positions with diameters approx. 3.3 mm where the cut was made. By viewing through the wall of the tube already on the stock, the scion was pushed into the tube so that its cut surface was guided across and matched to the cut surface of the stock. Scions generally consisted of a single lignified node 3 cm in length from which the leaf was excised. All buds on the stock were also excised using a scalpel. Grafts were tied to a small stake,covered with a plastic bag which was also tied, and placed in a plastic enclosure in a shaded greenhouse. When scion buds grew out, humidity in the bag was reduced gradually by opening the bag; the wall of the silicone tube was cut open using a scalpel when the bud grew out.

RESULTS

The viability of conventional grafts of mature scions is presented in Table 1 and show that 64% of oak clones gave at least one viable graft and 15% of all grafts were viable. Results for ash were superior.

Table 1. Viability of oak and ash grafts over 3 years using scions collected from crowns of mature trees (10 plants grafted per clone per year).

	Percent viable grafts (No. clones viable/no. grafted)			Mean % graft viability	Mean % clone viability
	1991	1992	1993		
Ash	91% (34/34)	97% (24/24)	96% (17/17)	96.6	100
Oak	17% (28/41)	10% (17/28)	17% (11/19)	14.7	63.6

First experiments with summer "tube" grafting used 4- to 8-month-old stocks and scions of oak and ash. Stocks and scions were selected with a diameter of approximately 3.3 mm to fit into a silicone tube with an internal diameter 3.2 mm (Figs. 1-5). Viable grafts were obtained using a diagonal cut, whereas horizontal cuts failed. Outgrowth of grafted buds occurred in 20 days. Scions consisting of an apical bud, with either 1, 2, or 3 axillary buds each gave 50% graft viability, whereas single and double node scions each gave 60% viability (10 to 15 grafts per treatment). Stock plants in which the growth flush had finished gave 50% graft viability, whereas those in which the flush was in progress gave 25% (12 plants per treatment).

Nonflushing stock plants and single node scions were used in further experiments. Scions from 9-month-old oak plantlets were grafted to their own rootstocks (autograft) or to another plant (heterograft) to test the effects of time delays, between collecting the scion and making the graft union. Delays of 10 sec, 1 min, 5 min, and 10 min were allowed before applying the scion to the stock. In each treatment with 15 plants, 100% of grafts were viable, indicating no adverse effects of delaying the joining of stock to scion or of rootstock type. Similarly, there was no difference in graft viability between using thicker stock and scion (within the range 3.4 to 3.5 mm).

The tube method was tested using mature clones of oak, already established from 2-year-old winter grafts. The single node scions were prepared by first removing the shoot apex between 4 and 7 days before excising the selected first node (N1) or second node (N2). Grafting was in August. Control grafts were seedling scions heterografted and viability was 68%. Unlike conventional winter grafting, all mature clones grafted were viable: two gave 100% viability while five out of the remaining six gave more than 30% (Fig. 6), (10 grafts per clone).

Eight elite trees of *Q. petraea* at Tullynally Castle, Co Westmeath provided scions from crown and epicormic shoots. Using the tube method in August 1995, crown shoots gave 55% viable grafts for one clone and 5% for another. The mean viability of grafting epicormic shoots was 7% with these eight clones (range 0 to 12%; 15,to 55 grafts per clone) and three clones failed to give viable grafts.

Scions were collected from a 20- to 25-year-old tree of *Q. coccinea* 'Splendens'. A total of 52 single node scions (3.2 mm) were grafted to *Q.robur* rootstocks in July-Aug 1995 and resulted in 29 (55%) viable grafts. This cultivar was also conventionally grafted in Feb 1996 and three grafts out of 48 were viable (B. Murphy, Pers. Comm.)

For tube grafting of ash, scionwood was collected from 2- to 3-year-old grafted stock plants of elite selections. Single nodes were selected and grafted in June-July 1995 onto 18-month-old rootstocks (Table 2).

Table 2. Viability of *Fraxinus excelsior* grafts using the tube method.

Clone	Number grafted	Number viable
Athenry 4	9	8
Athenry 7	20	15
Athenry 8	20	15
Jenkinstown 47	10	10
Shillelagh	10	9
Cong 2	13	13
Thomastown 70	14	13
Total	96	83 (86%)

The tube method was also tested during the conventional winter period of grafting in 1996, using multinodal scions and paraffin waxing. Viable grafts were obtained for *Sorbus megalocarpa, S. harrowiana*, and *S. sargentiana*. With the latter species, silicone tubing with an internal diameter of 9.8 mm was used to hold the graft union. In winter grafting of *Quercus*, the tube method was compared to elastic ties using scions from stock plants of five elite clones. All grafts were waxed and the viability averaged 38% with the tube method and was 27% with elastic ties. In grafting of *Betula jacquemontii* by the tube method and elastic ties, viability was 52% and 48%, respectively.

DISCUSSION

The skill of the grafter is especially important in aligning cambial layers and obtaining a secure graft union, especially with very thin scions. Summer scionwood

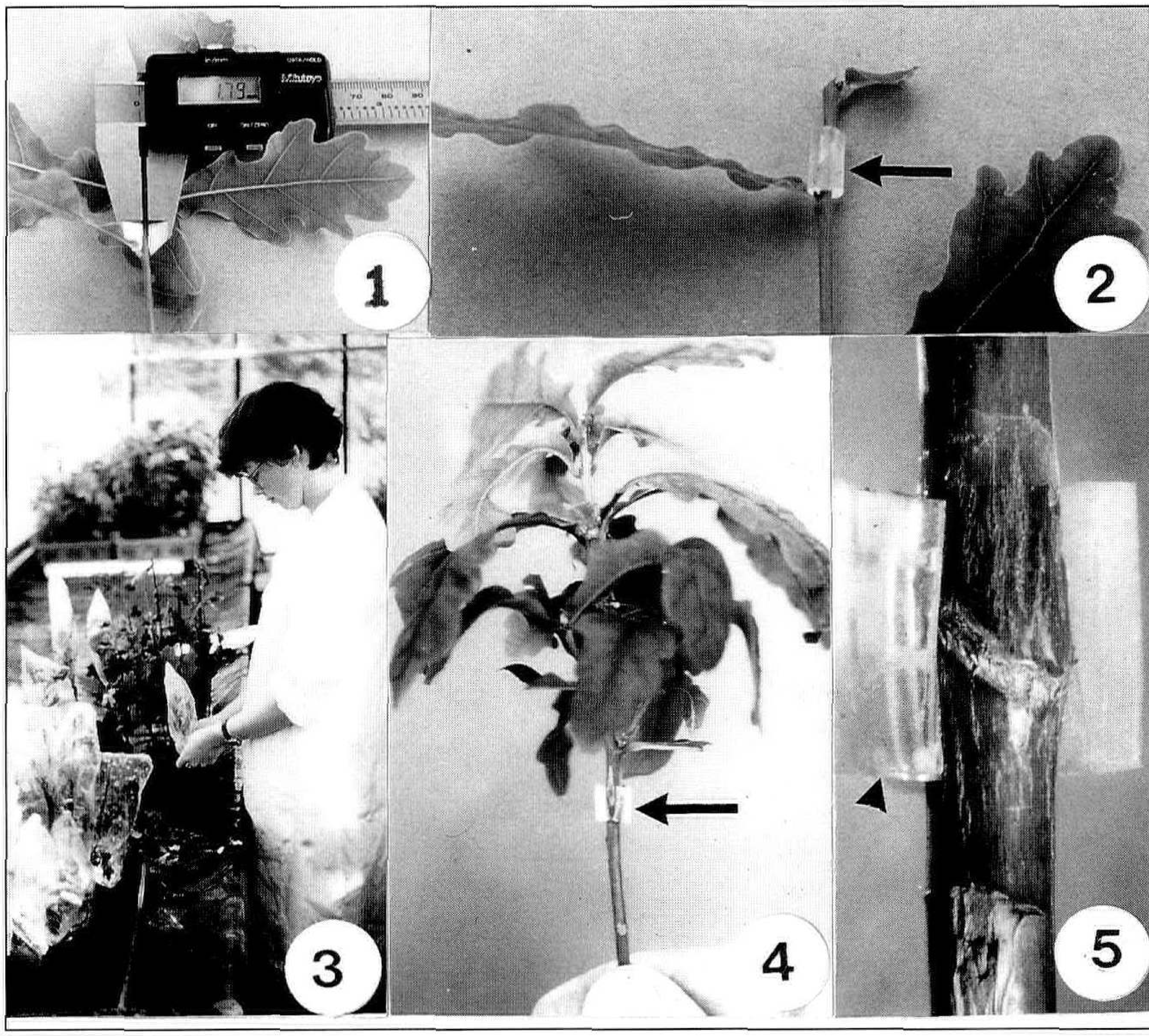

Figure 1. A digital calipers to measure stem diameter.
Figure 2. A single node of oak grafted using a silicone tube.
Figure 3. Staking and bagging after grafting.
Figure 4. Oak graft after 8 weeks.
Figure 5. Detail of an ash graft after 4 weeks (arrows show tubing).

of oak and ash is generally thin and difficult to hold with elastic ties. With in vitro grafting of stems 0.9 to 1.3 mm., Gebhardt and Goldbach (1988) first used a silicone tube with a longitudinal 'S' shaped incision in the tube wall to hold unions of *Prunus domestica* and *P. cerasus*. Olbeidy and Smith (1991) devised an aluminum coil for 4.0-mm-diameter apple and citrus.

When using intact pieces of silicone tubing, it is essential to use a caliper to select the stock and scion with the same stem diameter (or 1 to 2 mm greater) as the internal diameter of the tube and to carefully cut the tubing, once the scion bud grows out (Figs. 4, 5).

The elasticity of silicone tubes ensures an even pressure at the graft union which may facilitate cambial divisions and differentiation of vessels (Brown and Sax, 1962). The translucent silicone allows a rapid and easy alignment of the scion with the stock. Previous studies in grafting variegated clones of *Q. robur* in the dormant season gave 32% successful grafts by using an omega shaped graft union (Borzan, 1993) and 52% of *Q. robur* 'Fastigiata' scions grafted to 5- to 10-mm-root pieces (Leiss, 1988). Grafting of *Fraxinus excelsior* var. *pendula*

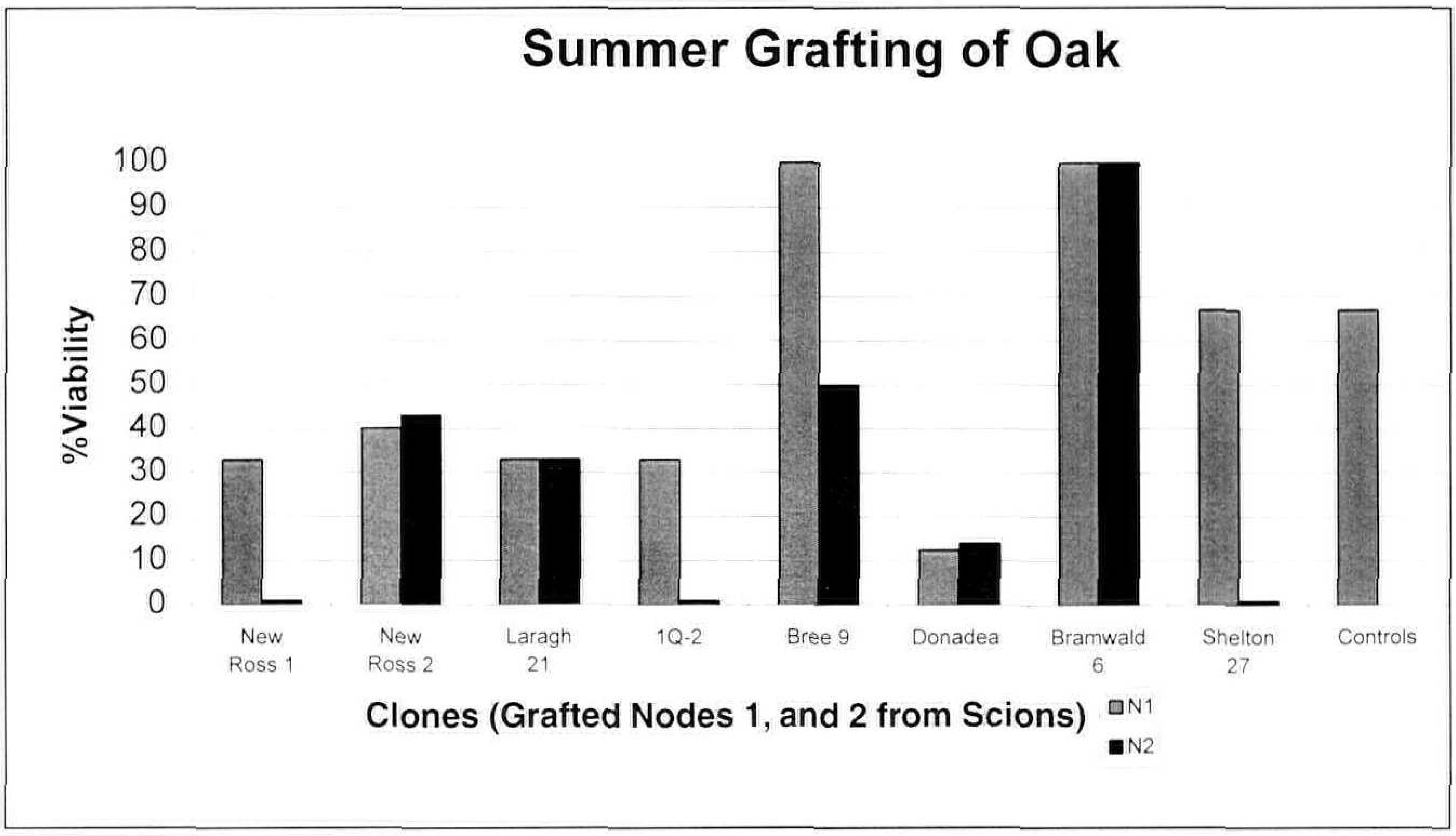

Figure 6. Summer grafting of oak by the tube method.

was 100% by pre-selection of buds using x-rays (Krsstev, 1994).

Studies on grafting *Q. palustris* 'Crownright' and 'Sovereign' suggest that virus-infected rootstocks may lead to graft failures and that *Q. rubra* scions which had isoperoxidase enzymes in common with those of the stock resulted in successful graft unions (Santamour, 1988). In the present study our average viability for oak was 15% and this contrasted with 97% for ash using scions collected directly from mature trees and conventional grafting in spring.

Summer grafting of oak in 1993 with the tube method gave consistently high graft viabilities in seven out of eight clones and with three clones, the viability was equal to or greater than the viability of control seedlings. In this experiment, scions were obtained from previously grafted stock plants and their potentially more rejuvenated condition may have contributed to increased graft viability. Good viabilities by tube grafting of crown and epicormic scions taken directly from several mature *Q. petraea* and *Q. coccinea* 'Splendens', suggest that the tube grafting in summer is a promising option for propagating oak.

Conventional winter grafting and summer tube grafting of ash gave high viabilities (86% to 100%) and with *Betula jacquemontii*, the tube method applied in winter gave similar viabilities to elastic tie grafting. Tube grafting in the growing season offers the prospects of improved rates of viability, especially for oak. However, the most important advantages of the tube method are:

- Grafting can be performed in summer when scion and rootstock vigour are high.
- Juvenile seedling rootstock can be used.
- Several successive grafts of the same plant can be made in one season.

By lengthening the season with supplementary lighting, at least three flushes of oak can be obtained and this allowed us to make three successive grafts in one season, by the tube method. Repeated grafting of new growths from mature scions to juvenile seedlings in vitro has rejuvenated *Persea americana* (Pliego-Alfaro and

Murashige, 1987), *Sequoia sempervirens* (Franclet, 1983), *Sequoiadendron giganteum* (Monteuuis, 1986), *Thuja plicata* (Misson and Giot-Wirgot, 1985), *Citrus* (Huang et al., 1992), and *Larix decidua* (Ewald and Kretzchmar, 1996).

The rootability of conventional cuttings from these grafted plants had improved in most cases as well as in material from nursery-grafted eucalyptus (Franclet, 1983), *Hevea* (Muzik and Cruzado, 1958), and *Persea* (Shafrir, 1970). In *Citrus*, repeated grafting of mature scions to germinated seedlings resulted in a progressive rejuvenation. Rooting of cuttings from grafted plants was 0%, 45%, and 70% from plants which were four, five, and seven times grafted respectively (Huang et al., 1992).

There is insufficient knowledge about the number of grafting cycles required to restore rooting competence to cuttings from mature ash and oak. However, by using the tube method of grafting, several successive grafts are possible per year and restoration of a juvenile physiology may be accelerated.

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