Bud-Grafting Difficult Field-Grown Trees

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Despite the widespread use of chip-budding, which enables faster and more complete union formation between rootstock and scion compared to traditional T-budding, there are various ornamental trees for which bud-take in the field remains unreliable and inconsistent among years and in different nurseries. Generally, the chance of success was increased by completing budding by early August, and by ensuring that rootstocks were growing vigorously during the budding period to ensure maximum cambial activity. Chip-buds of *Acer platanoides* 'Crimson King' are prone to dying before unions have formed, and experiments suggested that a root-derived factor is important in maintaining the viability of the scion during the slow union-forming process. Bud-take was correlated closely with the extent of root growth, and was depressed severely if root growth was restricted. It was necessary to avoid physical damage to the large buds of *Betula pendula* 'Dalecarlica' which was caused by pressure from the rootstock stem as it swelled within the budding tie. Degradable rubber ties which did not cover the actual bud were preferred. On the other hand, the use of polyethylene tape to cover the small buds of *Robinia pseudoacacia* 'Frisia' provided adequate pressure to ensure the differentiation of tissues in the rapidly developing callus, which otherwise enveloped the scion-chip without forming a union.

INTRODUCTION

A high percentage bud-take and the production of good stands of uniform trees are essential for commercial success when raising ornamental trees in the field. This is mainly because most production costs — such as those associated with the preparation of land; the purchase, planting, and maintenance of rootstocks; the production of scionwood; and the budding operation itself — are incurred irrespective of success rate and the proportion of first-grade trees harvested.

If nursery operators cannot understand how to achieve consistently good results with a particular subject, their inclination is to bud more rootstocks in the hope of achieving adequate numbers of trees. This makes the process increasingly cost ineffective. It is much more cost-effective, and hence profitable, to improve techniques and management so that higher yields are obtained from less work. During the 1970s the widely used T- or shield-budding technique was shown to be anatomically less efficient than chip-budding, which provided close cambial contact between rootstock and scion, resulting in rapid union formation. The use of chip-budding resulted in stands of fruit trees with greater uniformity and higher quality, compared to those from T-budding (Howard et al., 1974). The anatomical superiority associated with chip budding was confirmed subsequently for a range of ornamental trees (Skene et al., 1983).

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[1] Retired 31 Jan. 1997.

Despite this technical progress, there are ornamental trees which remain difficult to produce because bud-take is inconsistent between years and between nurseries. Three species in particular were investigated at HRI-East Malling, *Acer platanoides*, *Betula pendula*, and *Robinia pseudoacacia*. This paper summarises the main reasons for unreliable bud-take in the context of their particular characteristics.

MATERIALS AND METHODS

General experimental conditions are described here, with those specific to particular experiments referred to when describing the results.

Rootstocks and Planting Conditions. One-year-old rootstocks of *A. platanoides*, *B. pendula*, and *R. pseudoacacia* were obtained from a commercial source and held in a jacketed cold store at 2C until planted into a well-drained sandy loam soil that had been fumigated the previous autumn with chloropicrin. Spacing was at 40 cm in the row, with varying distances between rows to reflect plant vigour. Trickle irrigation was applied as required.

Scionwood and Budding. *Acer platanoides* 'Crimson King', *B. pendula* 'Dalecarlica', and *R. pseudoacacia* 'Frisia' scions were obtained from severely winter-pruned stockplants, with the leaf removed at collection to leave a short section of petiole. Budsticks were kept cool and moist at all times by wrapping them in damp hessian and were usually used within 8 h of collection.

Budding was by the chip method (Howard, 1974) at a height of 15 cm. The bud was held in place with a 25-mm-wide strip of either transparent polyethylene or degradable rubber, as indicated in particular experiments. Bud-take was assessed at the time of releasing the ties, again the following spring, and finally in relation to the number of trees harvested, which are the data referred to in this paper.

Relevant Characteristics of the Rootstock-scion Combinations.

***Acer platanoides* 'Crimson King'.** Union formation is relatively slow, with budding ties needing to be retained for 6 weeks, which is 2 weeks longer than for other species. Low bud-take appears to be associated with the inability of the scion-chip to survive and, often when ties are removed even after 6 weeks, the chip is found to have produced little or no callus and to detach easily from the rootstock; frequently the scion-chip is stained black with a water-soaked appearance. In contrast, copious callus is produced from the exposed cambial region of the rootstock stem.

Earlier work showed that inconsistencies among years were not weather-related but were associated with the field in which the budding was done (Howard, 1993); the experiments described for *A. platanoides* focused particularly on possible field-related factors.

***Betula pendula* 'Dalecarlica'.** Scion shoots on the budwood trees grow rapidly but the lower axillary buds develop into laterals, leaving only distal buds available for budding. These are large, prominent and soft, and often they fail to grow in the spring following budding despite the bud-chip appearing to have formed a union. Rootstocks often stop growing early in summer if the weather is dry or cool, or if they are damaged by residual herbicides. Experiments with *B. pendula* focused on the apparent need to bud rootstocks while still growing rapidly, and the need to avoid physically damaging the bud.

***Robinia pseudoacacia* 'Frisia'**. Rootstocks grow rapidly and are often excessively thick when budded. Polyethylene budding tape constricted the stems sometimes so that they would break during strong winds. This led to the routine use of degradable rubber ties, but high levels of bud-take were rarely achieved under these conditions, and experiments with *R. pseudoacacia* focused on whether the use of rubber ties was appropriate.

RESULTS

Acer platanoides 'Crimson King'.

Root Activity. Bud-take was compared for rootstocks grown in 2.0-litre pots, in the field, and in 75-cm-deep sand beds. Over a number of years major and consistent differences were obtained, with typical bud-takes of 33%, 77%, and 100% for pot, field, and sand bed, respectively.

The poor results for pot-grown rootstocks were obtained irrespective of large differences in shoot growth caused by growing under polythene or outside, and the consistently high bud-take in the sand beds was obtained irrespective of large natural variations in rootstock vigour.

Detailed measurements of root systems showed that the mean length per plant of structural roots for pot-, field-, and sand-bed-grown rootstocks was 420, 575, and 1260 cm respectively; examples are shown in Fig. 1.

The importance of root growth was confirmed when bud-take was increased on average from 20% to 53% when pot size was increased from 2.0 to 7.5 litres. Conversely, in the field bud-take was reduced from 79% to 13% by enclosing root systems in porous mesh bags at planting. The chance of bud failure was less where roots had escaped from the neck of the mesh bags.

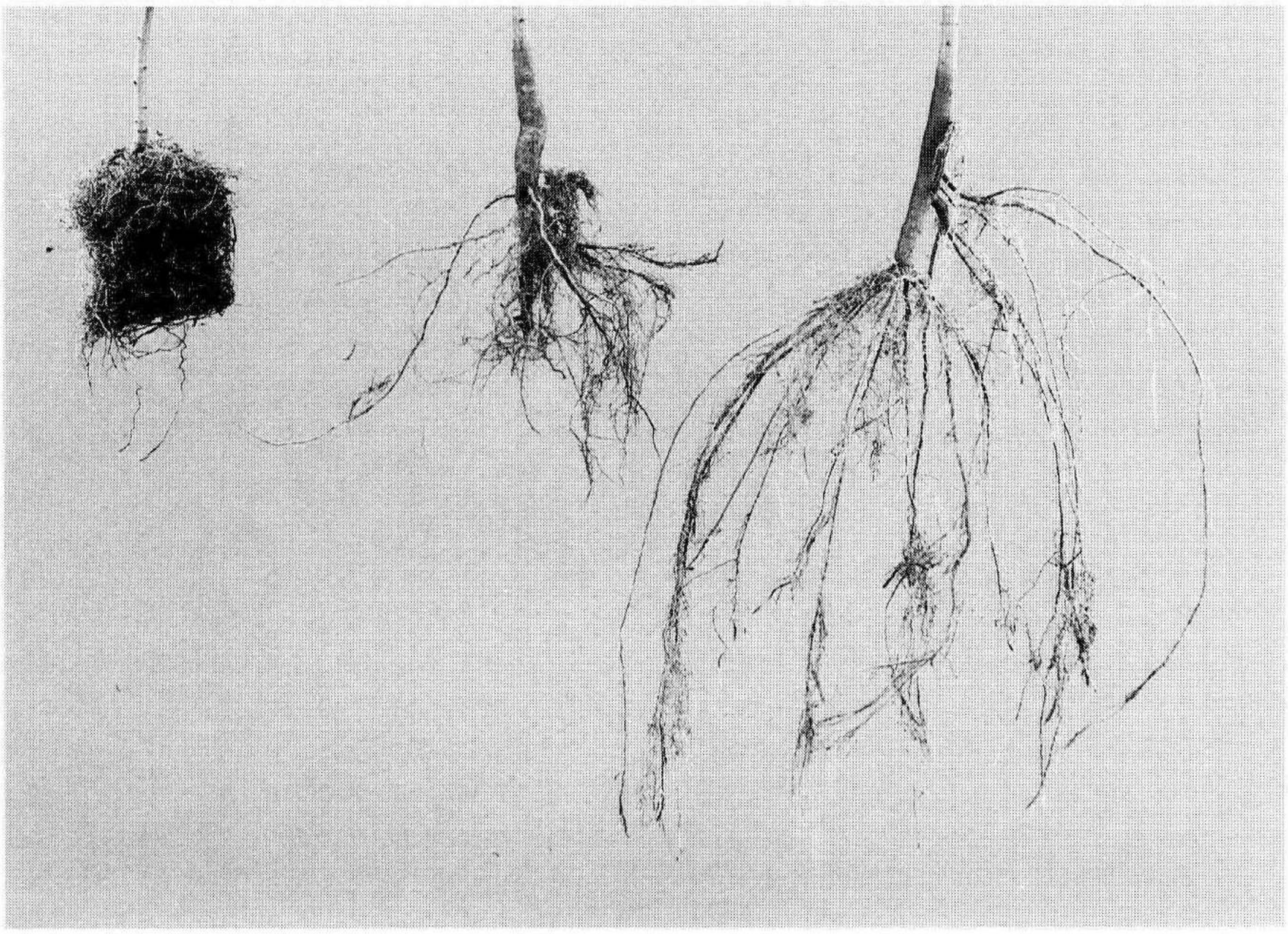

Figure 1. *Acer platanoides* root systems grown in, from left to right, a 2.0-litre pot, the field, and a sand bed.

Timing of Budding. Delaying budding from 2 Aug. to 23 Aug. decreased bud-take significantly from 83% to 52%.

Factors found to be Unimportant. The size of rootstock at planting (within the approximate 5- to 10-mm diameter range) had no effect on subsequent bud take. Various treatments aimed at altering the water status of the rootstock were also ineffective and, contrary to the view held by nurserymen, the considerable bleeding of xylem sap from the cut stem for 1 or 2 weeks following budding was not associated with budding failure. There was little influence from obtaining scion shoots from trees grown by various methods in pots and in the field, and neither was there an influence of the position of the bud on the budstick.

Betula pendula 'Dalecarlica'.

Rootstock Growth and Budding Dates. In *B. pendula* 'Dalecarlica' many of the first-formed buds develop into laterals. Consequently there is a tendency to delay budding until late August or early September. Although this proved very successful in some years it cannot be relied upon because, in dry or cool summers, or where damage occurred from residual herbicides, rootstock growth, and hence cambial activity, decreased rapidly and bud-take was reduced.

Budding on 2 Aug. and 6 Sept. was compared for rootstocks planted on 1 March or 16 May. Late planting, aimed at prolonging rootstock growth into late summer, proved feasible as long as rootstocks had been maintained in good condition in a jacketed cold store and were established with the benefit of irrigation if required. Early budding and late planting combined to give the maximum rate of stem swelling (cambial activity) at the time of budding. Budding in early August gave 82% bud-take, irrespective of when rootstocks were planted, but there was a benefit of late planting for September budding, which improved bud-take from 23% to 47% compared to normal early planting. Bud-take was reduced significantly also by reducing severely the number of shoots growing on the rootstock prior to budding; this is linked closely to a reduction in cambial activity.

Bud Ties. The possible importance of physical damage to the scion bud was investigated using treatment combinations of rubber and polyethylene, with the tape covering or not covering the actual scion bud. Budding took place on 10 Aug., 24 Aug., and 7 Sept. to determine the effect of pressure on the covered buds declining as growth rate reduced through the growing season.

Bud-take increased with progressively later budding, by using rubber rather than polyethylene ties, and by not covering the bud. These results reflected the extent to which buds had been flattened under the tie, often leading to failure, or to weak trees the following spring. Following budding on 10 Aug., a bud-take of 66% from the rubber-not-covered treatment was reduced to 48% with polyethylene, and to 29% when the polyethylene tape covered the bud. After budding on 7 Sept., a bud-take of 97% from the rubber-not-covered treatment was reduced to 88% using polyethylene and to 75% when the polyethylene tape covered the bud. The superior results from the latest time of budding compared to the earliest budding were associated with an approximately five-fold reduction in the rate of stem swelling, reduced flattening of the bud, and many fewer trees in the following year with weak maiden shoots.

Data from budding on 24 Aug. are less easy to interpret, with all treatment combinations falling within the range 64% to 67% for bud take. However, the

smallest maiden trees were produced by the polyethylene-covered treatment (147 cm) and the largest by the rubber-not-covered treatment (231 cm), suggesting that the debilitating processes observed in the earlier treatment were still operating, but at a reduced level.

***Robinia pseudoacacia* 'Frisia'.**

Bud Ties. A comparison on 1 Aug. between rubber and polyethylene ties covering or not covering the actual bud gave 83% bud-take with polyethylene covering the bud and 23% with rubber not covering the bud. This was in complete contrast to *B. pendula* 'Dalecarlica'. Other treatment combinations gave intermediate results. Initially, a high proportion of rubber-tied chip buds appeared to have formed a union, but these failed to produce trees and were prised easily out of the rootstock, suggesting that they were held in place simply by the enveloping rootstock callus.

DISCUSSION

Chip-budding is a technically sound procedure which facilitates rapid union formation, and so it provides a basis on which to investigate other factors that might cause inconsistent and often low levels of bud-take.

Rapid growth of the rootstock during budding provides the necessary cambial activity, which was a requirement common to all species. This was best guaranteed by budding not later than early August in south-east England, with the added option of delaying the planting of rootstocks so that their peak growth coincided better with the availability of mature budwood. Later budding, which is feasible using the chip-budding method because the "bark" does not have to be lifted as in T-budding, can produce excellent stands of high quality trees, but there is a risk in not being able to predict the onset of cold weather.

The rapid growth of some rootstocks has implications for the way the chip-bud is tied in, because the swelling rootstock stem can be constricted within the budding tie. This causes physical damage to the chip, and especially the bud, if this is covered. The large soft buds of *B. pendula* 'Dalecarlica' are particularly sensitive, so degradable rubber strips should be used which do not cover the actual bud.

In contrast, the small sunken buds of *R. pseudoacacia* 'Frisia' were not subject to physical damage, and pressure from the polyethylene tie was required to prevent the formation of a large pad of undifferentiated rootstock callus which held the scion-chip in place, but without forming a union.

The relationship between root growth and bud-take in *A. platanoides* 'Crimson King' revealed the complexity of the physiological processes which influence bud-take. It is proposed (Howard and Oakley, 1997) that failure in this subject is because the chip bud cannot remain viable during the prolonged period needed for union formation, despite completely wrapping the chip and bud with polyethylene tape, which caused no damage to the small buds of this cultivar. It is possible that a plant growth regulator produced in the roots, such as cytokinin, is required to maintain the chip-bud in a viable condition and that this is transported in the copious xylem sap which bathes the chip-bud, especially when root growth is particularly active.

Further evidence that special steps need to be taken to maintain 'Crimson King' chip-buds in a viable state comes from the fact that prophylactic fungicide sprays applied to the rootstock, and the dipping of the budwood, are beneficial and partly offset the detrimental effects of impaired root growth. Because there is no regulatory framework at present for the use of fungicides in this context, results are not given in this paper.

Acknowledgements. This work was funded by the Ministry of Agriculture, Fisheries and Food, and by the Horticultural Development Council. Technical assistance from Mr. J. Vasek is warmly acknowledged. Figure 1 is reprinted by permission of the Journal of Horticultural Science and Biotechnology.

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