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APRC Project Report

PROJECT: Technical improvements in fruit tree propagation
Project Staff: Jonathon Keyte; Dr. B.H. Howard (supervisor).
Date: June 1992

This new project is now getting underway at East Malling aimed at overcoming problems and creating opportunities in the fruit nursery that will work through to the benefit of growers establishing new orchards.

Among the first topics being researched are ways to produce larger maiden pear trees, methods for increasing the quality of highworked Queen Cox trees on M9 (budded at 30 cm), and changing the management of scionwood trees of colour mutants so that fruit can be observed close to the scionwood being taken for budding, thus reducing the risk of reverted budwood being used.

In addition, ways are being sought of improving the propagation of new rootstocks produced by fruit breeders at East Malling and elsewhere so that their products can be tested commercially as soon as possible.

Mr.Jonathan Keyte has been appointed to work with Dr.Brian Howard, Head of Propagation Science Section. Mr.Keyte has experience of commercial fruit nurseries and comes to East Malling from RHS Wisley, where he was the fruit technician with special responsibility for propagation and orchard management.

Mr.Alan Todd has agreed to act as the industry link, and growers and nurserymen are asked to make him, or the East Malling staff, aware of other problems that might be addressed in this project, in addition to those outlined above.

Project SP52 **Technical improvements in fruit tree propagation**
Dr. B.H. Howard and Mr. J. Keyte
October, 1993

Introduction

The background and staffing of this project were described in the last report and the objectives remain broadly the same, although the opportunity is being taken to prepare for new initiatives when the demands of the ongoing work allow. These include work relating to different sources of M.9 rootstocks, and work to optimise feather production in super spindles.

New insights into hardwood cutting propagation, mother-tree management and maiden tree growth have been obtained in the current work, which provides a useful framework in which to consider more detailed treatments. The relevance of work to develop new rootstocks for pears, and to increase the quality of pear maidens, increases in the light of APRC interests in promoting improvements in pear production. It is hoped that material from our nursery trials will feed through to an extended pear programme.

Progress to date

1. <u>Propagation by hardwood cuttings of potential new rootstocks</u>

Four quince rootstocks were re-tested and five new ones included, none of the latter showing much propagation ability. It will be unwise to judge them on the basis of this test because cold, dry weather in spring delayed planting-out until shoots were in an advanced state of growth, which caused the re-tested clones to perform poorly also. Although 1992 results showed that these quinces could be spring-propagated, they may perform better in autumn when buds are dormant, and this will be tested this year.

Despite the difficulties of the season pear cuttings established relatively well. Six previous and one new clone were tested, each with four treatment combinations (thick v. thin cuttings x ± basal wounding) comprising 10 cuttings each. All cuttings rooted in one treatment combination in clone QR 708/2 and in three treatment combinations in clone QR 708/36. The equivalent of 70% or better was achieved in two other clones, while two previously tested clones and the new clone performed relatively poorly.

For apple, all but one of the 1992 tests were repeated and eight new clones introduced, with the same treatment combinations as for pear.

Four clones performed well in at least one treatment combination, giving the equivalent of between 70 and 90% establishment (AR 69/7, AR 295/6, AR 360/19, AR 486/1).

Given the advanced age of the hedges planted originally as arboretum material by the plant breeders, even better results might be expected from hedges maintained specifically for propagation purposes. The eight quince, seven pear and ten apple clones established as stoolbeds all grew well and will be layered for their first season.

2. <u>Improved maiden tree quality for pears</u>

Timing of heading-back to the early summer-inserted bud was identified last year as the crucial factor in promoting growth from cold-stored scions, but the earlier this was done the thinner was the rootstock stem and thicker was the scion stem.

This year's experiment with Conference/QA compared two budding dates (26th May and 25th June), each with three dates of heading-back the rootstock top (after 3½, 5½ and 7½ weeks from budding).

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Most buds grew although some shoots in the 7½ week treatment rosetted, and there was die-back on the quince stem in a number of stocks on the opposite side to the scion, indicating the need to retain a rootstock shoot as a "sap drawer".

Treatment combinations of budding date and cutting-over time gave consistent effects across the replicated blocks. The May budding, 5½ week heading-back combination gave the tallest whips (43 cm) by the end of the season. The 5½ week heading-back treatment was also best after June budding, but the shorter growing season resulted in whips averaging only 37 cm, growth possibly being curtailed this year by early onset of cool weather.

The consistent advantage of retaining the rootstock head for 5½ weeks, compared to either 3½ or 7½, suggests that this is the best compromise between the early removal of the rootstock head reducing root growth, and its late removal imposing a high level of dormancy on the scion bud *via* an apical dominance effect. Detailed treatment responses support this hypothesis.

Next season's experiments will attempt to induce taller scion growth within the context of this proposed mechanism.

3. Modified mother tree management

Summer- and autumn-collected data are still being assessed, but the trial now comprises two parts; the conversion of well-established traditionally hard-pruned mother trees so that coloured fruit are borne near the source of scionwood, and newly established trees that can be managed from the start to achieve that objective.

The established trees of Queen Cox, Fiesta and Jonagold which were severely, moderately and non-pruned in 1992 spring had all useable annual shoots removed at budding time in August of that year. Last winter this gave the opportunity for only thinning-out branches and retaining short shoots with flower buds (dards and brindles) not suitable for scionwood. These were more numerous on the initially unpruned tree and so for the second season it was this tree that produced the highest number of coloured fruit close to annual scionwood. The budwood taken in 1992 from the non-pruned mother tree of Queen Cox produced normal maiden trees, but that from Fiesta and Jonagold developed into flower buds so that the maiden developed from the bourse shoots, which grew at poor angles resulting in overall poor quality maidens of these two varieties. This conflict between achieving good fruiting on the mother tree without it being carried over in the scionwood will need to be resolved by modifying the balance between the vegetative and flowering stimulus. New trees, either severely pruned or non-pruned, were brought into the experiment for Queen Cox to maintain the extreme effects while subsequent modified pruning in the second year blurred the effects of the initial treatments.

A new planting in its third season of Queen Cox and Red Gala on MM.106 and MM.111 was brought into the project this year, with three pruning treatments, namely hard-pruned, pruning as for free-spindle trees, and the third treatment not pre-determined, but modified each year in an attempt to maximise the coloured fruit/scionwood association. Although these trees are only at their formative stage it is clear that, in contrast to the conversion of old trees, the problems with young, open, free-cropping trees is to achieve worthwhile quantities of bud-wood, especially for the less vigorous Queen Cox. Most budwood was obtained from the 'flexible' pruning treatment.

Project SP52 **Technical improvements in fruit tree propagation**
REPORT: **Dr. B.H. Howard & Mr. J. Keyte**
March, 1994

1. Propagation by hardwood cuttings of potential new rootstocks

Since last reporting in October 1993 last year's established cuttings have been harvested, graded and recorded and new cuttings planted. With two seasons' data now available we can begin to see consistently ready-propagating clones within overall yearly fluctuations.

Apple clones AR 69-7, AR 628-2, AR 360-19 and AR 295-6 appear the most promising from a hardwood cutting propagation standpoint. The first three of these are expected to have vigour control of the same order as M27, so in view of the difficulty of propagating M27 the prospect of replacement clones which propagate more readily is pleasing.

Material from these and other clones is in the process of being distributed via the Apple and Pear Breeders' Club, and the next stage will be to bulk-up for Pomology trials to assess their effects on tree size, cropping and particularly fruit size and quality. There is close liaison with Dr. A.D. Webster for this purpose.

In February 1994 a total of 19 potential new clones was under propagation tests.

All four promising clones described above are included among eight clones being established as more conventional stoolbeds, along with M27, M9, and MM106 controls, and to which three new clones of M9 derived from tissue culture have been added this spring in parallel with testing their performance in the budding nursery.

It is not possible to comment on the continued development of new quince rootstocks because last year's propagation was poor, the suspected reason being delayed planting from the heated propagation bins because of cold dry weather, which resulted in advanced shoot growth being present. The current 1993/4 trial examines the relative advantage of propagating these early leafing quince cuttings in autumn when buds have not received their winter chilling, and hence remain dormant. Early observation shows the autumn-planted cuttings to be growing-away well, but results will not be assured until May. At least two clones, QR 193-16 and QR 530-11 have already shown good propagation by hardwood cuttings. The latter is expected to produce trees smaller than on Quince C with good yield efficiency.

Both quince clones which appear to propagate very freely from hardwood cuttings are included in the new stoolbed development, with four others and Quince A and Quince C controls. One new quince clone was added to the stoolbeds this winter.

Clonal *Pyrus* rootstocks are being developed for chalk soils, and although the hardwood cuttings need many spines removed at collection, there is surprisingly high rooting and establishment in some clones, including QR 708-36 with over 90% establishment in two successive years. Four other clones also look promising but have shown less yearly consistency, which will be further assessed this year when seven clones are being retested. *Pyrus* clone 708-36 appears to induce heavier cropping according to the pomologists than either Quince A or C without being more vigorous than Quince A. Seven *Pyrus* clones including QR 708-36 are being stooled, with one addition this year.

As with potential new apple clones early bulking will result in accelerated screening and assessment in orchard tests.

2. Improved maiden tree quality for pears

Trials continue to investigate whether larger-than-normal Conference trees can be produced in the two-year nursery cycle by budding in the spring of the first year, when the quince rootstocks are establishing, and inducing a whip in the same season.

Last October we reported that budding date and the time of removing the rootstock head appeared critical, with early budding in late May preferred, and with cutting-back to the bud after 5½ weeks giving a reasonable compromise between adequate thickening of the rootstock stem and promoting reasonable scion growth.

Trees produced in the first trial one year earlier have now been recorded and results indicate the need to consider treatment effects on tree shape and hence quality. A wide range of maiden tree quality can be produced, depending on which scion buds on the whip develop in the second season. Typically, a number of strong competing stems can grow in the second year from the least dormant distal buds which develop close together as the small first year whip stops growing in the autumn. Currently, as preparations are being made to take the 1993 whips into the 1994 season there is clear need to remove this zone of congested buds to improve lateral spacing, and this is easily done by either minimal pruning, or rubbing-out all but one of the buds in the cluster.

The new 1994 experiment investigates even earlier budding, including immediately after planting the Quince A rootstocks using cold-stored budwood. The effect of rootstock size is also being investigated, remembering that early removal of the rootstock head prevents stock thickening below the scion bud, and hence the need for thicker stocks initially.

3. Modified mother tree management

This component of our work aims to identify problems and opportunities for ensuring that reverted branches in mother trees of coloured sports are quickly identified to minimise the chance of the wrong trees being planted.

Queen Cox is the main subject, with Red Gala recently included, and further information being sought by using normal Fiesta and Jonagold because of their fruit-colouring characteristics.

The programme approaches the problem from both the conversion of normally severe-pruned mother trees to ones bearing more fruit, and the establishment of new mother trees where the correct balance of budwood and adjacent well-coloured fruit can be induced from the start.

In neither case is there likely to be a simple rule-of-thumb approach, because, particularly with the conversion of previously hard-pruned mother trees, there is carry-over of earlier effects.

Leaving a previously severely-pruned mother tree unpruned resulted in the required coloured fruit developing close to the source of budwood, and copious supplies of budwood on these large trees. However, typical budsticks taken to the budding nursery and budded onto M9 rootstocks showed that many were in the process of developing into flower buds on the annual wood, although this was not obvious when budding in mid-August. The resulting blossoms in the following spring meant that axillary buds grew out and formed wide-angled and poorly-shaped maidens, particularly in the case of Jonagold and Fiesta. The current aim is to find the correct pruning balance to maximise coloured fruit and minimise the development of fruit buds on scionwood. A pruning regime is being sought which will ensure that fruiting is confined to spurs near to the scionwood, but that scionwood vigour is not compromised.

Each year data are collected to describe the location and frequency of coloured fruit, the quantity and grade of bud-wood, and the performance of the budwood for raising maiden trees, but there appears little point in reporting at this level of detail until the desired pruning regime can be described.

The newly established mother tree block compares a typical hard-pruning treatment with a free-spindle method giving two tiers of well-exposed framework. Again, a third treatment not relating to existing approaches but having characteristics of cordon production, and which is sympathetic to the required balance of coloured fruit and generous scionwood is proving best. Basically this is a central leader tree with a permanent lower tier and a renewal upper tier, both of which carry centres of budwood production close to fruiting spurs.

4. Other topics

Ongoing work seeks to understand better the role of rootstock shoots retained in the budding year on the subsequent quality of high-worked Queen Cox maidens. The retention of shoots on the normally cleaned rootstock stem is sometimes essential in order to obtain good maiden growth the following year, but results are inconsistent and appear to indicate that this approach to rootstock management is a feature of drier sandy soils. In collaboration with a commercial nursery, it is hoped to compare the benefit of rootstock shoot retention on both sandy and stronger soils.

In addition, Queen Cox is being raised to investigate methods of restricting lateral extension in the maiden year to minimise the risk of barewood in trees destined for intensive slender spindle systems.

Project SP52 Technical improvements in fruit tree propagation
Dr. B.H. Howard and Mr. J. Keyte
October, 1994

Introduction

This project, which ends in June 1995, is continuing to make progress in each of its sub-objectives, and the ground is being prepared should it be possible to do further work to enhance orchard performance through improved nursery tree production.

1. Propagation by hardwood cuttings of potential new rootstocks

The main objective this year was to understand and remedy the disappointing establishment of quince hardwood cuttings in particular, during Spring 1993, which was associated with dry cold conditions after planting cuttings that had developed early shoot growth in the heated bins, and which could not survive before roots had established in the outside beds.

The approach was to investigate autumn propagation, before cuttings had received their winter chilling, and hence, before bud growth could occur.

Although Spring 1994 did not provide the severe test of the previous year, propagation in Autumn 1993 gave results which generally surpassed those of any spring propagation, and certainly those of Spring 1993. Comparisons for last year are shown in Table 1, where it can be seen also that seasonal effects are larger than those due to thickness of cuttings, and that a number of new quince and *Pyrus* clones propagate as readily as Quince A and Quince C given the right conditions.

We can conclude that early leafing subjects are best propagated in the autumn, while recognising the slight risk that occasional extreme low winter temperatures in the order of -10° to -15°C would damage cuttings planted out in the previous autumn. The next stage is to examine the possibility of ensuring against this by rooting cuttings in the autumn while dormant, but cold-storing over winter and planting out after the risk of severe weather.

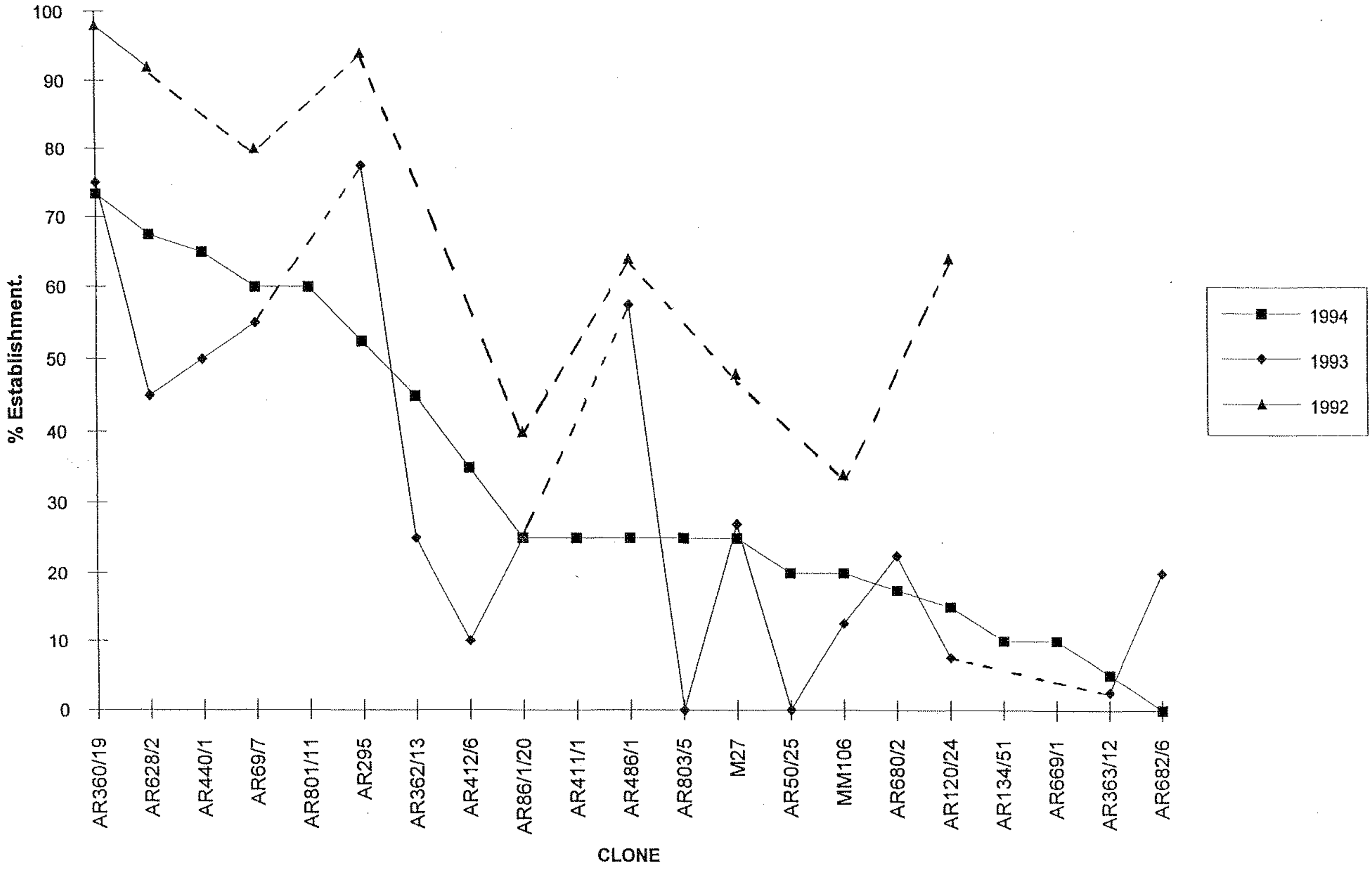
The NSA foundation stock of quince clone QR 193/16 will be propagated by hardwood cuttings this autumn, and in addition to harvesting and grading the 1994 established cuttings of all clones shown in Table 1, the first stoolbed crops will be harvested so that we can assess the extent to which performance of clones when propagated as hardwood cuttings translates into performance when stooled.

Potential new apple clones have been subjected to a range of treatments aimed at improving their rooting, and not all clones have been available for testing each year. However, despite this background variation, when the most comprehensive 1994 data are arranged with clones in descending order of establishment (Figure 1) there is evidence of some consistency being provided by data from previous years. The best six clones are clearly easier to propagate than M.27 and MM.106, and again the extent to which this predisposes them to perform well in the stoolbed will soon become clear.

Table 1. Hardwood cutting establishment (%) of potential new quince and *Pyrus* rootstocks

	Propagation season				
	Autumn (Nov. 1993)		Spring (Feb. 1994)		
	Thick cuttings	Thin cuttings	Thick cuttings	Thin cuttings	Means
Quince					
QR193/16	100	100	90	70	90
QR196/9	100	100	90	40	83
C51	80	90	60	50	70
QR193/13	70	95	70	10	61
QR196/8	90	85	30	30	59
C84	30	60	40	70	50
QR530/11	50		50		50
QR528/3	80	40	40	30	48
QR447/54	90	90	0	0	45
C132	40	20	40		33
QR715/3			50	10	30
QR530/18	0		50		25
C85	40	40	10	0	23
QA	100	80	70	50	75
QC	100	100	100	70	93
Means	69	75	53	36	
Pyrus					
QR708/36	100	100	100	100	100
QR708/63	50	65	90	90	74
QR107/2	70	90	40	70	68
QR708/2	90	100	30	30	63
QR517/9	90	100	10	10	53
QR708/23	70	60	20	20	43
QR107/1	70	55	0	0	31
Means	77	81	41	46	

Figure 1. Establishment of apple hardwood cuttings



2. Improved maiden tree quality for pears

Conference trees budded last year on Quince A have progressed from either whips developed in 1993 from early spring budding of that year, or from dormant eyes budded during August 1993 as normal. This year's growth will be recorded after leaf fall, but it is clear that the combinations of early summer budding and reasonably quick heading-back, especially budding in May and heading-back after 5½ weeks, can produce tall 'maidens' with useful laterals. Following careful management, and especially the time and extent of removing rootstock shoots and lower laterals, the conventional maidens of this year are of much better size and quality than normal, giving some opportunity to understand also how this can be achieved regularly. However, about 25% of these broke at the union during summer gales, whereas none of the early-budded trees failed.

The ongoing analysis of how to improve Conference trees in the nursery has pointed to the need for even earlier budding onto thicker rootstocks, along with the better selection of buds at the tip of the first year whip with respect to high feather production in the second year. Budding immediately after planting rootstocks in March of this year (more convenient than budding on the bench before planting) has given taller whips than the hitherto best treatments. Many of these scions exceeded 60 cm from the ground by this autumn, giving the opportunity to experiment with feather induction next year from existing buds above 60 cm, or from axillary buds that will develop at the base of next year's extension growth. Early indications are that laterals forming on next year's extension growth will be better balanced and spaced than those emerging from buds laid down at the tip of the whip this year.

3. Modified mother tree management

Work continues to understand how best to manage mother trees of coloured sports so that the scionwood collected annually for budding is associated with coloured fruit, thus minimising the risk of propagating reverted buds.

Examples of our traditional severely-pruned mother trees were 'converted' in winter 1992/93 by only lightly pruning them, or not pruning at all. The effect of this on the performance of budwood propagated in Summer 1992 has been reported already (Report for October 1993), notably the production of poor Fiesta and Jonagold maidens from the non-pruned source due to development of flower-buds that were not obvious at budding.

Most of the current mother trees are these originals, with pruning in the second year aimed at reducing the excessive responses to the original lighter- or non-pruning treatments. For Fiesta and Jonagold the enhanced production of coloured fruit on originally non-pruned trees remains, with no loss of budwood compared to the originally severely-pruned source, whereas for Queen Cox the benefit of colour fruit remains, but the number of usable buds was reduced compared to the originally severely-pruned trees.

Buds taken for propagation in the second year, after the attempt to 'level out' extreme pruning responses, did not show excessive flower bud production as in the first year. Detailed measurements will be taken on these maidens after leaf fall, but on the basis of visual grading varietal differences are greater than mother tree effects. Jonagold produced many trees with multiple stems that required singling, and it was also most susceptible to breakage at the union in summer gales.

Of more general concern is that less severe pruning of established mother trees causes them to become crowded, counteracting the development of good colour in the fruit, and exacerbating the problem of scab, which this year was difficult to control and led to the premature defoliation of many budsticks.

The new phase of this work, which is aimed at constructing more appropriate mother trees from the time they are planted, holds more promise than does conversion of existing old trees. Extreme treatments of severe-pruning versus free-spindle development are being compared, together with a system designed specifically for the purpose of producing a large number of budsticks close to well-coloured fruit. This system has a lower tier of branches and a more vertical head to give good light penetration, with each branch treated as a cordon on which spurs carry both the annual shoots for budwood and a coloured fruit to authenticate that budwood. This has proved very successful for the relatively vigorous Royal Gala, giving twice as many authenticated buds as the next best treatment. For the less vigorous Queen Cox trends are similar, but there is a tendency to encourage too many fruit at the expense of shoots. Early bare wood needs to be avoided, and subsequent excessive fruit set higher up the branches needs thinning to create the correct balance.

Project SP52 Technical improvements in fruit tree propagation
Dr. B.H. Howard and Mr. J. Keyte
March 1995

Introduction

Progress since the last report in October 1994 has been largely through the detailed harvesting and recording of rooted and established hardwood cuttings, of stoolbed production, and growth of maiden trees.

This project ends in June 1995, and various opportunities have been presented to Council for continuing improvements in the supply of nursery material to growers, including a change of emphasis, whereby the work on authenticating mother trees would be reduced to enable new work on the nursery implications for spread of nectria canker to be investigated.

1. Propagation by hardwood cuttings and by stooling of potential new rootstocks

Autumn propagation of quince and *Pyrus* hardwood cuttings gave higher establishment levels than spring planting, overcoming the problem of planting-out cuttings with active shoot growth from heated bins after winter chilling. In all cases except for thin cuttings propagated in spring, the highest yield for quince was in the largest size grade. Thin quince cuttings propagated in spring established least well, and had very few plants in the largest size grade. The trends for *Pyrus* were less clear but spring-planted thin cuttings again gave the lowest yield of large harvested plants, many more plants being obtained in all grades when autumn-planted. In both species propagating thin cuttings in spring should be avoided (Table 1).

A number of potential apple clones propagated better than M.27 and MM.106, and there was considerable clonal variation with respect to the grade-out of harvested plants. Overall, thick cuttings produced most plants in the top grade reflecting the effect of the initially thick shoots. Thin cuttings produced equal numbers of plants in each size grade overall (Table 2).

Although there were marked clonal differences, stoolbed production was higher for quince and apple than for *Pyrus* in terms both of the number of rooted shoots per stoolplant and the rooted shoots as a percentage of the total number of shoots produced (Table 3). A number of quince and apple clones performed at least as well as their controls (Quince A, Quince C, M.26, MM.106) and it is likely that rooting of *Pyrus* clones will improve as the vigour of individual (spiny) shoots decreases with the production of more shoots per stool in the second year. In contrast to production by hardwood cuttings most rooted quince shoots from stoolbeds were in the smallest size grade overall, but the trend was not as clear for apple stool shoots (Tables 4 and 5). Apple clones ranged from 0.7 to 9.2 rooted shoots per stool, higher production being associated with earlier cessation of shoot growth. Given that stoolbeds were not harvested until mid-December it is unlikely that to have waited longer for defoliation to occur would have increased rooting. The extended growing season of such clones is likely to prejudice their nursery use.

2. Improved maiden tree quality for pears

Maiden trees of Conference on Quince A raised by budding cold-stored scionwood in May of the rootstock-planting year (1993) produced tall, mainly unbranched but heavily spurred, trees by the end of the second year, combining approximately 40 cm of scion growth in the first year with 90 cm of growth in the second season. These trees were ideal for planting in V-shaped cordon

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systems and some are being trialled for orchard performance.

Growth in the second year from May-budding was virtually identical irrespective of the time the budding tie was removed and the rootstock headed-back, emphasising the importance of inducing maximum growth in the first year, activated by heading back and forcing the scion bud 5½ weeks after budding. Later budding produced hardly any growth in the first season, and small maiden whips were often immature and sometimes died in the following winter.

Controls budded as normal with current year's dormant scions in August producing much higher quality trees in the second (maiden) year than is normally the case for Conference. Maiden height averaged 118 cm, with an average of 5.6 laterals developing at a height of 50 cm or more above ground. All trees had evenly spaced and graded lateral shoots, and none produced the vertically growing lateral that is typical of Conference and which competes with the maiden stem.

It is not entirely clear why these well-formed trees suitable for free-standing systems were of such improved quality this year. A number of changes in nursery management will be investigated further, including the delay in removing rootstock shoots and lower scion laterals, which appeared to have the effect of stimulating upper laterals, enhanced by an increase in nitrogen fertiliser.

There remains the problem that 25% conventional well-feathered maidens broke at the union during summer gales compared to none of the spring-budded trees.

Rootstocks were budded with cold-stored budwood even earlier in 1994 than in previous years. Using a thicker grade of rootstocks it was found technically difficult to chip-bud rootstocks before planting in March, but budding was successful when done immediately after planting. Because establishment and growth was slower at this time of year, ties were left on and rootstocks not headed-back for eight weeks. To leave the rootstock intact for 10 weeks increased the risk of forcing the scionbud to grow at a wide angle and hence forming a bent union. Removing the rootstock head at eight weeks gave the best compromise between obtaining the tallest whip and a reasonably thick rootstock stem below the union because the developing scion compensated reasonably soon for the removal of rootstock shoots. Leaving rootstock tops intact for much longer increased further their stem thickness, but scion growth was minimal and less than half that obtained by heading back after eight weeks. This improved method gave maiden whips 72 cm tall in the year of rootstock planting, giving ample opportunity for bud-rubbing and lateral selection at 50 cm in spring 1995.

3. Modified mother tree management

Attempting to convert large severely-pruned conventional mother trees has not been successful despite remedial treatments following altering the pruning regimes in 1992. For the vigorous Jonagold almost no scionbuds were produced on branch structures located within three years growth of coloured fruit. For Fiesta, the 1992 lightly pruned treatment was most effective and for Queen Cox the non-pruned treatment gave the largest number of authenticated buds, owing to the increase in size following non-pruning (Table 6).

Representative trees from within a relatively new planting designed to produce ideal mother trees from scratch showed that Royal Gala produced the largest number of authenticated buds when grown on MM.111, especially by the specifically designed pruning system. Despite Queen Cox being a weaker variety than Royal Gala, most useful buds were produced on MM.106. In this case traditional severe pruning produced the greatest number of authenticated buds, but in relatively young small trees one coloured fruit tends to authenticate a large amount of scionwood, which may not be the case when severe pruning leads to excessive shading in larger trees. The relatively poor performance of the free-spindle system for Queen Cox is not because of a deficiency of either shoots or coloured fruits, but that shoot growth could not be removed as budwood without compromising the free-spindle shape (Table 7).

Table 1. Hardwood cutting establishment of potential new quince and *Pyrus* rootstocks with harvested plants shown in size grades (mm - stem diameter) as out of 10 per treatment, winter 1994/95

	Propagation season											
	Autumn (Nov. 1993)						Spring (Feb. 1994)					
	Thick cuttings			Thin cuttings			Thick cuttings			Thin cuttings		
Grades	5-6	7-8	9+	5-6	7-8	9+	5-6	7-8	9+	5-6	7-8	9+
Quince												
QR193/16	0	3	7	0	3	7	1	4	3	1	6	0
QR196/9	0	1	7	0	2	7	0	2	6	0	2	2
C51	0	4	4	0	3	6	0	2	4	3	1	1
QR193/13	0	1	6	3	5	2	1	2	3	1	0	0
QR196/8	1	4	4	3	3	3	0	0	3	0	2	1
C84	1	2	4	1	1	2	0	0	4	1	0	1
QR530/11	-	-	-	3	2	1	-	-	-	2	2	1
QR528/3	0	2	2	0	3	4	0	2	1	0	2	1
QR447/54	0	0	8	2	1	5	0	0	0	0	0	0
C132	1	3	0	2	0	0	-	-	-	3	0	1
QR715/3	0	4	3	2	6	0	0	1	4	1	0	0
QR530/18	-	-	-	0	0	0	-	-	-	0	0	0
C85	0	0	4	1	3	0	0	0	1	0	0	0
QA	0	1	9	0	2	5	0	1	6	0	3	2
QC	2	5	2	3	6	1	0	4	6	2	4	2
Means	**0.4**	**2.3**	**4.6**	**1.3**	**2.7**	**2.9**	**0.2**	**1.5**	**3.4**	**0.9**	**1.5**	**0.8**
Pyrus												
QR708/36	1	4	5	5	4	1	0	0	10	0	0	0
QR708/63	0	1	4	0	2	5	0	0	4	0	6	3
QR107/2	0	6	1	5	4	0	0	3	2	5	4	0
QR708/2	2	6	1	2	2	6	2	1	1	2	1	0
QR517/9	2	2	4	3	3	4	0	1	0	1	1	0
QR708/23	2	2	2	3	2	1	1	0	1	1	1	0
QR107/1	1	3	3	2	3	1	1	2	3	1	0	0
Means	**1.1**	**3.4**	**2.9**	**2.9**	**2.9**	**2.6**	**0.6**	**1.0**	**3.0**	**1.4**	**1.9**	**0.4**

Table 2. Hardwood cutting establishment of potential new apple rootstocks with harvested plants shown in size grades (mm - stem diameter) as out of 10 per treatement, winter 1994/95 (spring propagation only)

	Thick cuttings			Thin cuttings		
Grades	5-6	7-8	9+	5-6	7-8	9+
AR 360/19	-	-	-	2	2	4
AR 628/2*	-	-	-	0	2	5
AR 440/1	2	3	4	3	3	1
AR 69/7	3	2	1	5	2	1
AR 801/11	0	2	5	1	3	3
AR 295	0	2	3	3	4	1
AR 362/13	0	3	2	1	2	0
AR 412/6	0	0	2	1	1	1
AR 86/1/20	1	1	2	2	1	0
AR 411/1	1	0	0	2	4	4
AR 486/1	0	0	2	0	1	3
AR 803/5	0	0	3	1	0	2
M.27*	-	-	-	1	1	1
AR 50/25	0	1	0	3	1	0
MM.106	1	0	2	1	1	0
AR 680/2*	-	-	-	0	0	2
AR 120/242	1	1	0	0	1	1
AR 134/51	0	1	0	2	0	0
AR 669/1	0	1	0	0	1	0
AR 363/12	0	0	0	1	0	1
AR 682/6*	-	-	-	0	0	0
Means	**0.6**	**1.1**	**1.6**	**1.4**	**1.4**	**1.4**

* A high proportion of cuttings from the trunk

Table 3. Number of rooted harvested stool shoots (and % rooted) per stool plant

Quince			*Pyrus*			Apple		
	No.	%		No.	%		No.	%
QR 193/16	4.5	92	QR 107/2	0.2	9	M.27	3.3	79
QR 196/8	4.9	88	QR 517/9	0.2	6	MM.106	4.8	98
QR 447/54	5.6	77	QR708/2	0.2	3	AR69/7	4.0	89
QR530/11	4.9	92	QR708/23	0.5	12	AR86/1/20	3.8	83
C51	3.7	79	QR708/36	0.3	7	AR120/242	2.4	96
C84	3.6	95	QR708/63	2.5	37	AR295/6	6.5	88
QC	4.3	96	B661	0.1	7	AR360/19	2.9	100
QA	3.2	97				AR 362/1	0.7	33
						AR 486/1	3.2	63
						AR628/2	9.2	100

Table 4. Stool shoot grade-out (mm - stem diameter) as number of shoots per quince stool

Grade	5-6	7-8	9-10	11-12	Waste
QR 193/16					
Well rooted	2.5	0	0	0	2.3
Poorly rooted	1.8	0.2	0	0	2.0
Not rooted	0.1	0.2	0.1	0	1.5
QR 196/8					
Well rooted	2.8	0.5	0	0	1.4
Poorly rooted	1.2	0.4	0	0	1.1
Not rooted	0.2	0.2	0.1	0.1	1.2
QR 447/54					
Well rooted	1.1	0.4	0.2	0	1.0
Poorly rooted	2.3	1.4	0.2	0	3.2
Not rooted	1.0	0.6	0.1	0	6.5
QR 530/11					
Well rooted	3.2	0.6	0	0	1.4
Poorly rooted	0.7	0.4	0	0	1.3
Not rooted	0.2	0.2	0	0	0.6
C51					
Well rooted	1.5	0.2	0	0	0.8
Poorly rooted	1.4	0.6	0	0	2.5
Not rooted	0.9	0.1	0	0	2.5
C84					
Well rooted	1.8	0.8	0	0	0.8
Poorly rooted	0.6	0.4	0	0	0.5
Not rooted	0.1	0.1	0	0	0.6
QC					
Well rooted	3.3	0	0	0	12.7
Poorly rooted	0.6	0.4	0	0	0.5
Not rooted	0.1	0.1	0	0	0.6
QA					
Well rooted	2.0	0.5	0.1	0	1.2
Poorly rooted	0.5	0.1	0	0	1.3
Not rooted	0.1	0	0	0	1.6

Table 5. Stool shoot grade-out (mm - stem diameter) as number of shoots per apple stool

Grade	5-6	7-8	9-10	11-12	Waste
M.27					
Well rooted	1.7	0.6	0	0	0.8
Poorly rooted	0.9	0.1	0	0	1.4
Not rooted	0.5	0.4	0	0	3.5
MM.106					
Well rooted	0.6	1.4	1.7	0.7	2.8
Poorly rooted	0.3	0	0.1	0	1.5
Not rooted	0.1	0	0	0	2.7
AR 69/7					
Well rooted	1.0	0.6	0.4	0.1	0.8
Poorly rooted	0.7	0.6	0.5	0.1	1.3
Not rooted	0.3	0.1	0.1	0	1.0
AR 86/1/20					
Well rooted	0.2	0.9	0.3	0.2	0.3
Poorly rooted	0.9	0.6	0.4	0.3	1.7
Not rooted	0.1	0.4	0.2	0	1.9
AR 120/242					
Well rooted	0.6	0.4	0.5	0.1	1.8
Poorly rooted	0.3	0.5	0	0	0.2
Not rooted	0	0.1	0	0	0.2
AR 295/6					
Well rooted	1.8	1.0	0.7	0	0.6
Poorly rooted	1.6	1.0	0.4	0	2.0
Not rooted	0.5	0.4	0	0	1.6
AR 360/19					
Well rooted	1.3	0.5	0.6	0	3.5
Poorly rooted	0.3	0.1	0.1	0	2.1
Not rooted	0	0	0	0	1.3
AR 362/1					
Well rooted	0.2	0	0.1	0	0.3
Poorly rooted	0.1	0.1	0.2	0	0.3
Not rooted	0.6	1.0	0.5	0	1.6

Continued....

Grade	5-6	7-9	9-10	11-12	Waste
AR 486/1					
Well rooted	1.3	0.5	0	0.1	0.7
Poorly rooted	0.7	0.4	0.2	0	1.3
Not rooted	0.7	0.6	0.4	0.2	0.6
AR 628/2					
Well rooted	4.0	2.8	1.7	0.1	3.6
Poorly rooted	0.5	0	0.1	0	0
Not rooted	0	0	0	0	0.4

Table 6. Current authenticated budwood production of trees treated in 1992, and given remedial pruning to modify extreme responses in subsequent years. (Values in brackets are numbers of actual authenticated buds).

Treatments applied in spring 1992	Total number of scion buds available	Percent scion buds within three years framework of coloured fruits
Jonagold		
Severely pruned	2004 (100)	5
Lightly pruned	2147 (0)	0
Non-pruned	2828 (0)	0
Fiesta		
Severely pruned	1531 (92)	6
Lightly pruned	1022 (388)	38
Non-pruned	1115 (167)	15
Queen Cox		
Severely pruned	669 (140)	21
Lightly pruned	595 (143)	24
Non-pruned	1597 (399)	25

Table 7. Current budwood production of trees specifically raised to produce authenticated budwood. (Values in brackets are numbers of actual authenticated buds).

	Total number of scion buds available		Percent scionbuds within three years framework of coloured fruit	
Rootstock	MM.106	MM.111	MM.106	MM.111
Royal Gala				
Severely pruned	73 (69)	599 (365)	95	61
Free-spindle	107 (105)	168 (143)	98	85
Spur system	533 (490)	742 (646)	92	87
Queen Cox				
Severely pruned	756 (537)	585 (480)	71	82
Free-spindle	129 (101)	36 (26)	78	72
Spur system	403 (330)	487 (326)	82	67

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Project SP52 **Technical improvements in fruit tree propagation**
Dr. B.H. Howard and Mr. J. Keyte
October 1995

Introduction

This project has been extended for a further two years until March 31st 1997 with some important changes of emphasis.

In the light of the concern over current high levels of Nectria canker in apple and pear orchards, and the suggestion that this problem is exacerbated by infection lying dormant and/or becoming systemic in the trees, work has started to identify important sources of initial infection.

Outbreaks of canker in new orchards are usually scattered and often difficult to associate with known local sources of infection, raising the question of whether trees from nurseries are implicated. There is growing evidence that this is the case, confirming opinions and corroborating work done in the East Malling nursery in the 1970's.

The aim of the new work being done in collaboration with Professor Terry Swinburne of Wye College, is to contaminate rootstocks and budwood at vulnerable stages in the two year nursery cycle using a range of spore concentrations in the inoculum, in an attempt to identify the borderline between creating overt cankers and possible latent infection. If the latter can be confirmed by Professor Swinburne it will show that the transfer of apparently healthy trees from nursery to orchard can result in the observed scattered outbreaks of Nectria in newly planted orchards, given further evidence that such latent infection can erupt into visible cankers.

So far M.9 rootstocks have been inoculated in the wounds caused by trimming off shoots prior to budding, and budwood was contaminated at the time of budding. A further inoculation of the stump of the headed-back rootstock is planned in late winter, and next year it is hoped also to contaminate a stoolbed to see whether infection can be carried into the budding nursery from this source also.

Despite the additional work load it has been necessary to hold costs in check by reducing the time given to this project by the technician with day-to-day charge, Mr. Jonathan Keyte, but the 20% of his time saved has been redirected to the orchard testing of new clonal rootstocks, supervised by Dr. Tony Webster, thus providing a continuum with work in this project (SP52), where we facilitate the propagation and production of those new rootstocks, as set out below.

1. Propagation by hardwood cuttings and by stooling of potential new rootstocks

The very promising new quince rootstock QR 193/16, of similar vigour to Quince C and with equal precocity but larger fruit, was multiplied as EMLA virus-free stock, succeeding with eight out of ten cuttings propagated from a potted plant raised in an insect-proof gauze house, and established in a bed constructed in the same house. Attempts to root the distal parts of these shoots to avoid wasting material failed, confirming that rooting ability

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resides only in the basal part of the shoot. The eight well-established plants will form the nucleus of distribution to the NSA.

Future bulking-up might be accelerated by taking cuttings from newly established ones rather than waiting to establish hedges. In a small trial towards this objective with new quince rootstocks QR 193/13, QR 196/8 and QR 447/54 approximately half the number of these 'immature' cuttings that were propagated gave a well-established plant. With new *Pyrus* rootstocks QR 107/1, QR 708/36 and QR 708/63 the overall result was similar but the range between clones was greater.

General bulking-up of interesting new quince and *Pyrus* clones continued. The most promising quince clones listed in Table 1 of the March 1995 report were re-propagated, together with nine new clones not tested previously, and capable of dwarfing and/or increasing fruit size. Some of these established from hardwood cuttings at 100%, and only one below 50%. Similarly, with *Pyrus* rootstocks, the most interesting were re-propagated, along with six new clones, two of which established at or above 75% and all but two above 50% (Table 1).

Table 1. Percent establishment of quince and *Pyrus* rootstocks after propagation by hardwood cuttings, winter 1994/5. Clones not previously propagated are indicated *. (Note: although shown as percentages for convenience of comparison only 20 cuttings were available for most clones, and less in some cases).

Rootstock	Percent establishment	Rootstock	Percent establishment
Quince		*Pyrus*	
QR 193/16	100	QR 517/9	90
*QR 314/6	100	*QR 719/3	85
*QR 530/4	100	*QR 708/12	75
QR196/9	90	QR 708/36	65
C132	85	*QR 726/19	65
QR 530/18	82	*QR 706/1	55
*QR 530/5	82	*QR 311/7	25
*QR 530/9	80	*QR 515/24	0
*QR 522/1	75		
QR 715/3	70		
*QR 193/1	65		
*QR 523/1	65		
*QR 447/10	60		
*QR 191/3	30		
QA	100		
QC	100		

Earlier work showed that autumn propagation gives superior establishment of quince and *Pyrus* cuttings by avoiding planting them out in spring after bud-burst, which occurs early in these species. However, there is a risk occasionally of very severe winter frosts damaging the establishing cuttings after planting outside in December. To this end we have investigated the opportunity to root cuttings in the autumn, and then to hold them safely overwinter polythene-wrapped in a cold store at 2°C, before planting out in early March with less advanced bud growth than those propagated at that time.

In two quince clones (QR 447/54 and QR 528/3) cold-stored cuttings established as well as those planted in the autumn (and which in 1994/5 did not experience severe winter conditions). Both sources were superior to spring-propagated cuttings. In one clone (QR 193/13) cold storage gave inferior results to autumn planting and was only slightly superior to spring planting. The poor performance of cold-stored cuttings of this clone was associated with a disproportionate number sprouting even by 20th December, suggesting that it might be possible to pre-identify the type of cutting prone to early growth, and thus further improve establishment rates.

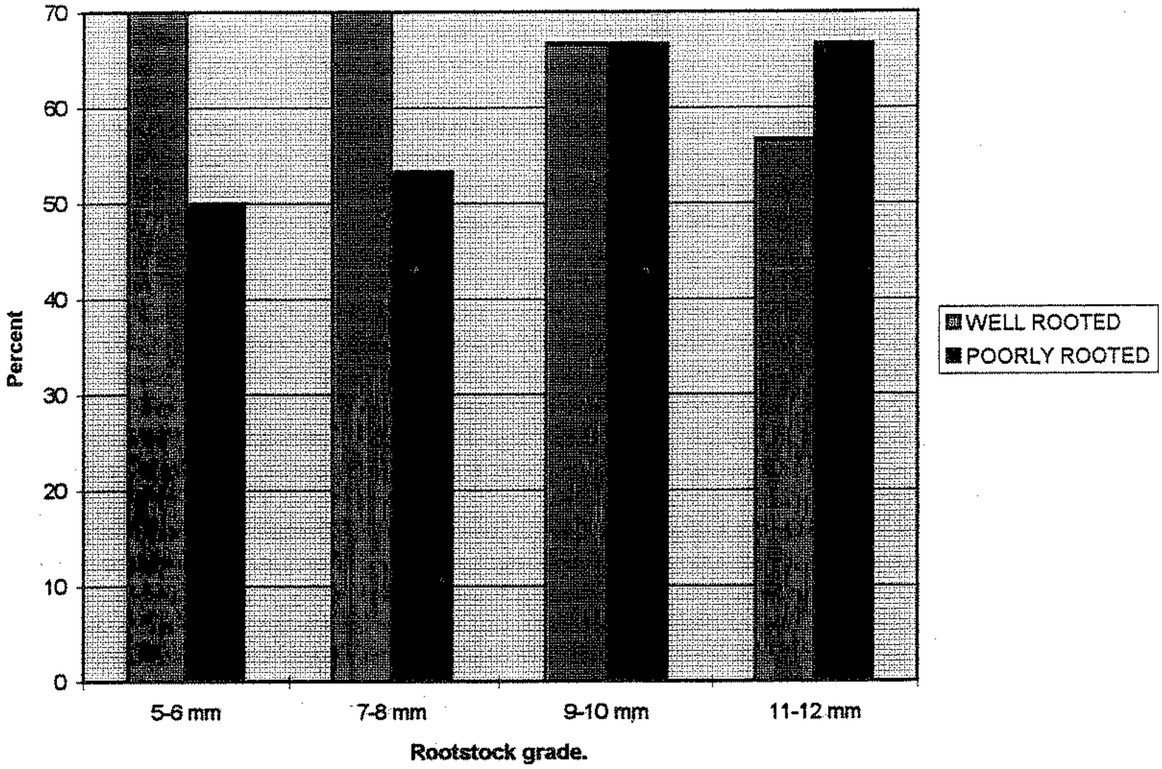
Propagation of the most promising quince and *Pyrus* rootstocks has been extended to include stoolbeds which will have their second harvest in winter 1995/6.

Four new clones of M.9 EMLA apple rootstock raised by micropropagation and with potentially higher rooting potential than the existing M.9 clone are being propagated by stooling and their effect on maiden tree production investigated; results of 1994 budding will be obtained this winter.

A preliminary investigation seeks to predict the possible performance of these new clones with improved rooting and shoot growth by creating different grades of conventional M.9 EMLA rootstocks in terms of rooting and stem thickness. For stocks classed as well-rooted at the time of planting those with stem diameter grades of 5 to 6 and 7 to 8 mm produced 70% first grade maiden trees of Queen Cox, with the number declining to 55% as stem thickness at planting increased. At the thickest grade of 11 to 12 mm the reduction in first grade trees was because a few rootstocks failed to establish and some maiden trees broke at the union during summer gales. Budtake was consistently high across all grades. For initially poorly rooted stocks a greater percentage failed to establish, especially in the 7 to 8 mm grade, and partly in consequence of this the number of first grade trees increased with thickness of rootstock. These results suggest that rootstock grades (and hence possibly new clones) should be separated and managed differently in the nursery, with well-rooted stocks discouraged from growing too thick, and poorly rooted stocks encouraged to grow well (Figure 1).

Among the new M.9 clones no. 86A and to some extent 86B produced at their first stoolbed harvest a high proportion of well-rooted 7 to 8 mm shoots of the sort which performed well in the preliminary grade-out trial. All new clones out-performed conventional M.9 EMLA in the stoolbed.

Fig. 1 Percent first grade Queen Cox maiden trees harvested on rootstocks of different thickness & degree of rooting when planted.



2. Improved maiden tree quality for pears

The results of the current experiment will be recorded this winter, but observations in the nursery already show clearly that two distinct types of high quality Conference maiden tree can be produced for different orchard use.

We have continued to improve the number of useful feathers on conventionally-produced maidens from traditional August-budding by exploiting the observation that when rootstock shoots and low laterals are removed the developing maiden responds by trying to replace them immediately in the zone behind the shoot apex of the developing scion. By initially encouraging rootstock shoots and low laterals to develop and then removing them in mid-June, five to six useful laterals developed above 60 cm, producing trees well-suited to conventional centre leader or delayed open centre use.

Budding rootstocks at the time of planting and obtaining scion growth in both the first and second nursery years produced tall, spurred trees suitable for super spindles, but which feathered only sparsely in the nursery. It is assumed that this is because these trees have few rootstock shoots and low laterals at the start of the second season, and hence there can be no stimulus to useful feather production by their removal.

3. Modified mother tree management

Work continues to understand the best way of producing budwood mother trees of coloured sports to enable coloured fruit to develop near to the source of budwood so as to reduce the chances of propagating reverted wood.

This summer, when trees were drought-stressed, the pruning systems that encouraged most fruit reduced the production of budwood, so that, for Queen Cox, the traditionally severely-pruned budwood tree produced more scionwood than trees spur-pruned or grown as free-spindles, with coloured fruit produced this year on these hard-pruned trees, whereas in years with more shoot growth fruit are infrequent and often green. For Royal Gala both hard-pruned and spur-pruned trees carried fewer fruit and more budwood than the free-spindles. Differences were enhanced in both varieties by the hard-pruned trees with lower fruit load also producing more scion buds per budstick.

Whilst this programme has demonstrated previously the general benefits of the spur-system for obtaining a balance of coloured fruit and useful quantity of budwood, it is clear that fruit will need to be thinned more drastically than was the case this year in order not to jeopardise budwood.

Budwood is taken each year from the differently managed scionwood trees for nursery budding tests, but it is becoming increasingly difficult to relate maiden tree quality to scionwood tree management in a simple way. Nevertheless, different scionwood tree management affects the type of budstick produced. Not surprisingly, pruning methods aimed at maximising fruiting increase the risk of carrying flower buds to the budding nursery to the detriment of maiden tree development in the following year. This is exacerbated in Queen Cox if buds are taken from the lower part of budsticks which have partly defoliated at the time of budding in mid-August, whereas in Jonagold, where there is no premature defoliation, flower buds are associated with vertical budsticks. The main detrimental effect during the maiden tree year is the production of twin maiden stems from axillary buds, implying loss or weakening of the main vegetative bud. In Queen Cox, Jonagold and Royal Gala the frequency of twin maiden stems was much greater than the frequency of blossom buds, and in Queen Cox, and to a lesser extent Jonagold, although there were certain cases where there was a close correlation between blossom buds and the development of twin stems, in other cases, and with Royal Gala, twin stems developed in the absence of blossom buds, suggesting that axillary buds can be stimulated without the main vegetative bud necessarily and obviously developing into a fruit bud and producing blossom.

The current year's budding experiment has largely ignored mother tree pruning effects and is investigating the influence on maiden trees of using budsticks markedly different in terms of their orientation and degree of defoliation, because it is clear that it will not be possible to be highly prescriptive over the management of scionwood trees, whereas it will be useful to indicate the types of budsticks to be aimed for or avoided.

Project SP52 **Technical improvements in fruit tree propagation**
Dr. B.H. Howard and Mr. J. Keyte
March 1996

Introduction

Changes in emphasis in this extended programme were outlined in the report for October, 1995, and this report describes progress in each of the sub-topics since then.

1. Nectria canker

In an attempt to demonstrate that outwardly healthy maiden trees can transmit *Nectria* infection from the nursery to the new orchard, a series of inoculations at different stages in the 1995-96 nursery cycle was completed in conjunction with Professor Terry Swinburne and Dr.Stephen Langrell of Wye College.

Three concentrations of spore suspension were applied to wounds caused by removing sideshoots from rootstocks in June, to budwood in August, and to the cut surface of the rootstock after cutting back to the scion bud in March. Cankers have already developed following the budding treatment in particular, and the full effects of treatments are expected to become obvious in late spring. Most attention will be focused on trees that appear to have escaped infection and which might be carrying internal and possibly systemic infection. An initial sample from 500 rootstocks has been taken to Wye to search for evidence of systemic infection. Earlier stages of the nursery cycle are being investigated by inoculating the cut surfaces of stools after the annual harvest of rooted stoolshoots, and the soil under the stoolbed. For this purpose an isolated section of M.2 stoolbed was used before the final grubbing of an old nursery site.

2. Propagation by hardwood cuttings, and by stooling, of potential new rootstocks

The results following harvesting of established hardwood quince, *Pyrus* and apple cuttings during last winter do not differ markedly from those described in the October, 1995, Report based on a record of the standing crop.

Comparisons of performance from hardwood cuttings compared to stoolbeds is of interest.

For *Pyrus* rootstocks the frequency of spines developing on the stool shoots has reduced only slightly following the second stoolbed harvest, and the difficulty of handling these plants, and the labour needed to remove the spines, remains a problem. In any case, stoolbeds cannot be recommended for *Pyrus* rootstocks because very few shoots rooted (Table 1). In contrast, rooting of quince shoots on the stoolbed was higher, but many shoots were too small or too large to be of use in the budding nursery, a problem which increased with increasing stoolbed age (Table 1). Among new apple clones AR295/6 was particularly prolific and equated with MM.106.

The advantage of hardwood cuttings for propagating *Pyrus* rootstocks may be attributed to the benefits of applying auxin and bottom heat, which is not possible on the stoolbed. The advantage of hardwood cuttings for propagating quince rootstocks is that shoots can be pre-selected on the hedge, where annual pruning aims to maximise the number of medium sized cuttings and where the smallest and largest shoots can be rejected, whereas on the stoolbed all shoots are retained through the season, and the smallest ones root preferentially.

Stoolbeds of M.9 EMLA apple rootstock raised from micropropagation out-performed stoolbeds of non-micropropagated M.9 EMLA, suggesting a degree of 'rejuvenation' (Table 2). When budded, maiden trees on the micropropagated M.9 rootstocks were marginally better quality in terms of height, stem diameter and numbers of useful laterals, indicating that the improved stoolbed performance was a real gain in production efficiency.

Table 1

Mean numbers of shoots per plant in different classes harvested from quince and *Pyrus* stoolbeds in 1994 and 1995

	Useable rooted shoots		Non-useable rooted shoots		Non-rooted shoots	
	1994	1995	1994	1995	1994	1995
Quince						
QR 193/16	4.5	1.9	4.3	9.1	1.9	3.6
QR 196/8	4.9	3.0	2.5	2.9	1.9	2.4
QR 447/54	5.6	2.3	4.2	8.0	8.2	12.1
QR 530/11	4.9	0.7	2.7	3.4	1.0	1.3
C51	3.7	3.9	3.3	6.2	3.5	3.8
C84	3.6	1.7	1.3	1.8	0.8	0.6
QC	4.3	1.5	13.2	16.9	0.8	3.3
QA	3.2	2.8	2.5	4.4	1.7	1.0
Means	4.3	2.2	4.3	6.6	2.5	3.5
Pyrus						
QR 107/2	0.2	0.1	0	0.7	5.3	3.7
QR 517/9	0.2	0.2	0	0.3	8.9	4.0
QR 708/2	0.2	0.5	0.1	0	9.0	8.8
QR 708/23	0.5	1.0	0.1	1.6	7.0	3.1
QR 708/36	0.3	0.4	0	0.1	9.2	12.9
QR 708/63	2.5	3.4	0.3	1.0	7.6	5.4
B661	0.1	0.3	0.2	0.5	4.9	6.7
Means	0.6	0.8	0.1	0.6	9.4	6.4

Table 2

Mean numbers of useable stool shoots per plant (i.e. rooted shoots between 5 and 12 mm diameter)

	1994	1995
Micropropagated clones		
78	2.8	6.1
82	2.6	5.8
86A	4.0	3.4
86B	3.3	6.3
M.9 control	2.0	2.5

Modified mother tree management

Scionwood that led to the production of shoots from secondary buds on the scion chip in addition to the maiden shoot, produced trees that were generally inferior in terms of height, numbers of useful laterals, and general grade, for both Queen Cox and Jonagold. The extent to which secondary shoots are a response to aspects of management, rather than a random response, is being investigated.

Modified maiden tree quality

Apple:

Attempts to reduce the length of laterals on maiden trees to avoid later bare wood were made by comparing the physical removal of lower laterals, so as to induce higher, shorter ones, with additional single and double sprays of Cultar at 1.3 g l^{-1} + Tween 20 wetter on 12th July (single spray), and 20th July and 3rd August (double spray). For Queen Cox the repeated Cultar spray slightly increased the number of laterals above a height of 60 cm and produced the shortest laterals (Table 3). For 'Royal Gala' the repeated Cultar spray gave trees which were amongst the best in terms of number and length of laterals, but the single physical removal of low laterals led to increased production of laterals above the 60 cm height which was not surpassed by the addition of Cultar. Differences between treatments were not large, but it is clear that Cultar sprays can be used to enhance 'legging-up' lower laterals in 'Queen Cox'.

Table 3

The effects of manipulating laterals on 'Queen Cox' maidens in 1995

	No. of laterals over 60 cm height	Length of lateral (cm)
Not pruned	5.7	9.8
Lower laterals removed 5th July	7.8	12.9
Lower laterals removed 2nd August	6.5	12.4
Cultar sprayed 12th July	7.3	9.4
Cultar sprayed 12th July and 3rd August	8.7	8.9

NB. Both Cultar treatments were preceded by removing laterals below 60 cm height on 5th July, which is the treatment against which responses to Cultar should be measured.

Pear:

Investigations into ways of improving lateral production in normal summer-budded 'Conference' on Quince A showed that the increase in laterals observed in recent experiments was due mainly to the double process of removing rootstock shoots relatively early once scion growth commences in early May, and then removing any re-grown rootstock shoots and lower scion laterals during late June and early July, when the Conference maiden had reached 70 cm. Under these circumstances laterals were repressed by the presence of rootstock shoots and lower scion laterals until their removal, and then scion laterals developed at about 60 cm where axillary buds had not yet become dormant. The retention of only the original rootstock shoots until the scion had reached 70 cm proved useful, but less effective. Of even greater benefit was the use of thicker (9-10 mm) rootstocks compared to 7-8 mm stocks. The combination of thicker rootstock and repeated stock shoot removal gave 5.8 laterals above 60 cm height, compared to 3.3 laterals on trees on thinner rootstocks and with only a single rootstock shoot removal. The diameter of the scion above the union benefited from repeated rootstock shoot removal because this encouraged an early flush of low laterals which thickened the stem. The rootstock leg below the union benefited from the single late rootstock shoot removal treatment, because the diameter of the rootstock increased in the presence of rootstock sucker shoots.

In comparison, trees were again produced over a two-year cycle by chip budding immediately after planting the rootstock, inducing a short whip in the first summer, with continued extension growth in the following year. The object was to induce laterals by tipping 'maidens' at 70 cm. However, pinching out the apex (including rolled but not expanding leaves), gave only a temporary check to growth and presumably also to apical dominance. Few useful laterals above 60 cm were formed, with the best treatment of budding in March of the previous year onto thick rootstocks and heading-back after eight weeks giving a mean of 2.6 useful laterals.

Until effective ways are found to induce more laterals this two-year production method is best used to produce cordon-like trees with the potential to fruit close to the main stem.

Trees from early stages in this work are being orchard tested under project SP73.

Project SP52 **Technical improvement in fruit tree propagation**

Dr. B.H. Howard and Mr. J. Keyte

October, 1996

Introduction

Aspects of the work to date are described in APRC News for October, 1996, and consequently there is some overlap between that and this six-monthly report.

1. Nectria canker

Concern that nursery trees carrying *Nectria* infection, but not necessarily visible cankers, could be planted in new orchards arises from earlier work at East Malling where it was shown that a small proportion of trees intentionally infected with *Nectria* during the budding process developed cankers after leaving the nursery. Current work by Professor Swinburne and colleagues at Wye College, which shows that *Nectria* can exist without obvious symptoms, gives credence to the possibility of carry-over from nursery to orchard, and fits with the often observed scattered infection of young orchard trees; (see article in APRC News No. 8, July 1995, pp 9-11 for an update on the apple canker situation).

Complementary to a major new MAFF- and APRC-funded research initiative led by Professor Swinburne, the aim of new work in SP52 is to investigate, in collaboration with the Wye team, the stages during nursery tree production where inoculation with canker spores could induce cankers in maiden trees and, more importantly, use a range of spore concentrations in the hope that some trees would not show overt cankers in the nursery, so providing the opportunity to seek evidence of internal infection and carry-over to the orchard.

The first objectives were achieved, with all spore inoculation treatments inducing cankers, and the frequency of canker development correlating with the spore concentration applied. The number of 'Queen Cox' maiden trees which failed to grow was highest where the M.9 rootstocks were inoculated before budding, due to cankers effectively girdling the stem below the union. Results to date are shown in Table 1, where it can be seen that more than half the trees are not showing cankers at the time of writing, and so provide an opportunity to investigate the risk of their later emergence in the orchard.

In August of this year the emphasis changed to assessing the risk of unwittingly distributing *Nectria*-infected trees from the nursery, by investigating commercial sources of 'Queen Cox' budwood. Samples from five nurseries were budded at East Malling and trees will be examined in subsequent years for the development of cankers in such a way as to distinguish between infection from the original nursery source and sources local to the budding nursery or new orchard.

Stoolbeds inoculated with *Nectria* spores in March 1996, by either spraying inoculum over the cut surfaces of harvested rootstocks, or infecting into the soil below the stool, are not showing visible cankers.

Table 1. Nursery inoculations with *Nectria*

Nursery stage when treated	Relative spore concentration	% trees with cankers	% maiden trees failing to survive
Pre-budding removal of rootstock shoots in June	low	76	18
	medium	80	28
	high	98	54
Budwood at budding in August	low	8	6
	medium	12	6
	high	42	34
Cut surface of rootstock when headed-back in March	low	8	4
	medium	22	18
	high	42	20
Control (inoculated with water only)		0	0

2. Propagation by hardwood cuttings and stooling of potential new rootstocks

The early propagation of new apple, quince and *Pyrus* clones is progressing routinely, identifying those which are relatively easy-to-propagate, and how the propagation technique can be improved for particular species and individual clones.

Twenty seven potential new apple rootstocks have been tested to date, with 14 progressing from hardwood cuttings to stoolbeds, together with 15 new *Pyrus* and 24 new quince clones. Approximately 30% have been forwarded to nursery members of the Apple and Pear Breeders' Club for bulking up and commercial assessment.

The opportunity for flexible management of hardwood cuttings used to propagate early-leafing quince rootstocks, while reducing the risk of losses from severe winter low temperatures, was confirmed by showing that autumn planting gives higher establishment than spring planting, but that if cuttings are rooted in autumn and held over winter in a jacketed cold store, they then establish in greater numbers than if propagated directly in spring. This is because the latter have broken dormancy and leaves are encouraged to develop during the heated-bin rooting period, reducing the chance of subsequent establishment. For quince clone QR528-3, autumn-propagated cuttings established at 75%,those propagated in the autumn and overwintered in the cold store established at 65%, and those propagated in the spring at only 25%.

3. Improving the quality of maiden pear trees

Growers often insist on planting two-year-old pear trees, partly because of the poor quality of varieties such as 'Conference' received as maiden trees, with one or two vigorous upright laterals competing wtih the leader.

Two methods have been devised for improving maiden trees produced in the normal two year cycle.

Improvements to trees produced by budding rootstocks in August and raising the maiden in the following year have been achieved by understanding the relationship between the quince rootstock shoots which emerge in spring of the maiden year below the 'Conference' scion bud, and also the role played by the first 'Conference' laterals that develop too close to the ground to be useful.

The early development of rootstock shoots and low scion laterals is the response of the young tree to the imbalance caused by cutting off the rootstock top in the winter after budding. Once rootstock shoots grow they suppress further lateral development but, when they are removed, the young maiden tree compensates by producing laterals from buds at the top of the current maiden stem, which are not yet dormant. Therefore, the timing of rootstock shoot removal will determine where scion laterals will be produced. In practice, the best trees are produced by removing the new season's rootstock shoots when the scion has grown for 2 to 3 cm in early May, allowing a second flush of rootstock shoots and the first low laterals to develop, all of which are removed in a second operation when the scion is approximately 70 cm tall. Good quality rootstocks and an adequately fertilized soil with irrigation enhance the lateral production response. The best trees produce an average of almost six laterals at a height above 60 cm.

The alternative method involves budding newly-planted rootstocks with cold-stored budwood, obtaining a whip in the first year, and further growth in the second year.

Despite erratic rootstock establishment in the dry, 1995, spring 38% of whips exceeded 80 cm height, 34% grew between 60 and 80 cm, and only 27% grew less than 60 cm. The largest trees were cut back to 70 cm at the start of the 1996 season, which forced axillary buds produced the previous year to form high branches and give well-shaped trees; these will be recorded in winter 1996/97.

Trees in the 60-80 cm category were cut back to 50 cm, forcing, on average, 7 branches which were too low to be useful. Removing these in mid-July failed to stimulate higher laterals on the new season's leader.

The group of trees with whips less than 60 cm in height were left unpruned and continued their terminal growth with no lateral development, giving the straight, spurred trees, described in earlier reports, suitable for various forms of intensive 'wall' systems.

'Concorde' has been introduced into this programme. In contrast to 'Conference', 'Concorde' stops growing relatively early, producing an average whip of only 59 cm compared to 88 cm for 'Conference'. Nurserymen also find that the quality of 'Concorde' trees is impaired by premature cessation of growth, the cause of which needs investigating.

REPORT TO APRC - PROJECT SP52

Technical impovement in fruit
tree propagation

March 1997

APRC Project Report

Project SP52	Technical improvement in fruit tree propagation
Project Staff:	Dr. R.W.F. Cameron and Mr. J.P. Keyte.
Date:	Report to 31st March, 1997

Introduction

This area of research has secured funding for a further three years, and work will continue under projects T13 - Nursery techniques to improve tree quality and rootstock propagation and MAFF OC 9518 - The significance of nursery inoculum sources in apple canker epidemiology.

Nectria Canker

Progress in this sub-project was described in the Report for October 1996, and in the APRC Newsletter, No. 12, p 9-11. Since then all trees with visible cankers have been grubbed and sections of stem bearing visible cankers removed and sent to Wye College for verification that cankers are *Nectria* induced.

The apparently healthy trees were lifted and transplanted, in an "orchard" situation at East Malling, thus simulating the commercial situation when they are sold on from the nursery. These trees will continue to be observed regularly for cankers which may indicate the presence of internal infection at the time of sale and hence the potential to introduce canker into new orchards.

To date, stoolbeds inoculated with *Nectria* spores at a high rate in March 1996 (either by spraying inoculum at 5.5×10^5 spores per ml over the cut surfaces of harvested rootstocks or by direct application at 1.83×10^4 spores per ml into the soil below the stool) have shown no visible cankers after stock plant harvest in 1997. These M.2 stocks will now be planted in a nursery situation, budded and monitored for any latent canker expression in the coming two years. The M.2 stoolbed will be retained and monitored for a further year, with no extra inoculum to be applied in 1997.

Propagation by hardwood cuttings and stooling of potential new rootstocks

Clones and species of interest were identified in conjunction with Dr. A. D. Webster to be bulked-up in 1995/96 for orchard testing. Apple rootstocks with vigour between M.27 and M.26 need to have good precocity, productivity and fruit size; stocks with vigour similar to MM.106 need improved resistance to collar rot (*Phytophthora cactorum*). Quince rootstocks are sought with the vigour of Quince C rootstock (or less), but with the ability to induce large fruit. Pear (*Pyrus)* rootstocks are required to provide well-anchored tree of modest size and good fruit quality to be grown on chalk soil, where trees on quince suffer from lime-induced chlorosis.

Quince QR 193-16 (similar vigour to QC, but with the advantage of promoting larger fruit size) produced from hedge material gave an establishment rate of 94%. This clone has merit as it not only propagates well but cuttings produced have fewer laterals to remove than Quince A. Clone QR 528-3 also propagates well, with 80% of cuttings establishing.

Generally however, success rate was reduced this year compared to previous years and this was demonstrated particularly with QR 193-13 (clone from the same parentage as QR 193-16 but not yet fully evaluated) which gave 48% establishment compared with almost twice that level in previous years.

Four clones of *Pyrus* rootstocks propagated in 1995/96 also showed reduced establishment compared to previous years, but this may be accounted for by the fact that the hedges had been left unpruned for a year. The objective of this was to utilise the many laterals produced on the hedges directly as cutting material. Even though general establishment rates were reduced, clone QR 708-36 (more vigour than QA but a precocious cropper with good to variable yield) still gave 80% establishment.

New clones of M.9

Three out of the four new micropropagated clones of M.9 have continued to out-perform M.9 itself in terms of stoolbed productivity during 1995-96 (mean number of rooted shoots between 5 and 12 mm diameter), with clone 86B producing 71% more than that of M.9.

In the 7-8 mm diameter grade alone, two of the new micropropagated clones, 86A and 86B, produced a higher mean number of rooted shoots, with the latter producing twice the number of rooted shoots (Figure 1).

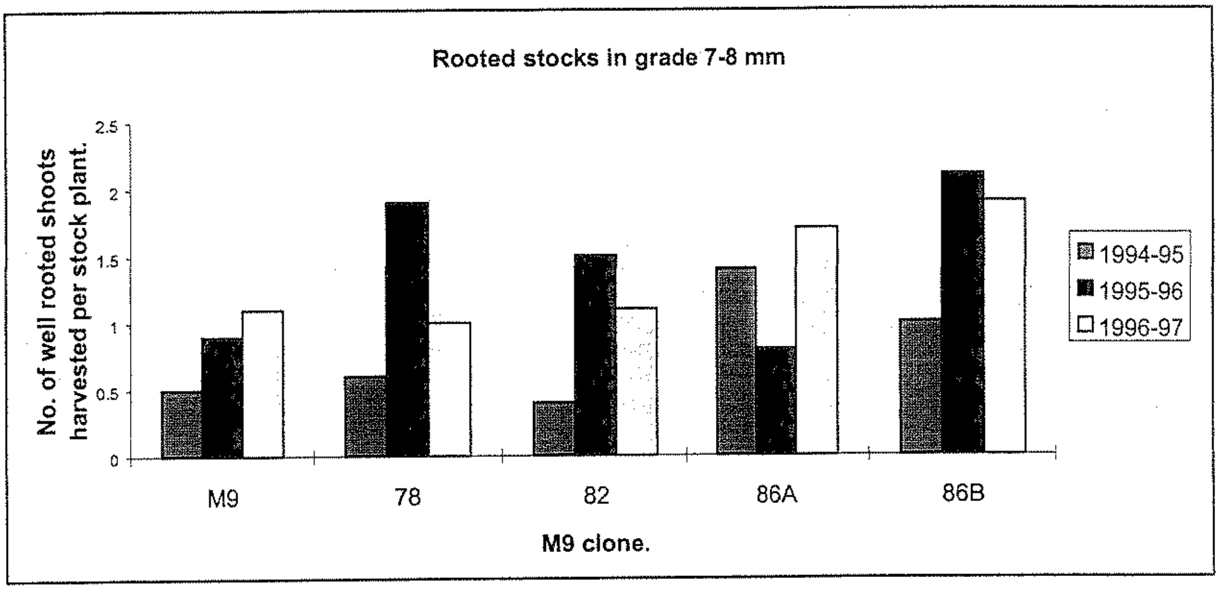
These M.9 clones have also been tested in the nursery and budded in 1995 with Queen Cox. The maiden tree grade-out during autumn 1996 was improved by 35% with clone 86A compared to the M.9 control (Table 1). Records are currently on-going with respect to the numbers of stock shoots requiring removal during nursery production.

Table 1.

Queen Cox maidens produced in 1996: Percentage grade-out according to rootstock clone

	Grade 1	Grade 2	Grade 3
Micropropagated clones			
78	78	24	0
82	88	12	0
86A	97	3	0
86B	86	14	0
M.9 Control	62	36	3

Figure 1.



Improving the quality of maiden pear trees

The influence of budding time for Conference on Quince A was compared. Rootstocks were either chip-budded in spring (March 1995) or budded conventionally in summer (August 1995).

In spring-budded trees, few if any useful laterals formed on the first year 'whip', nor did any laterals develop on the second year extension to the whip, but buds located near the top of the first year whip grew out as lateral branches in the second year if the whip was pruned back to a high bud during the intervening winter. Results showed clearly that the main requirement is to obtain a whip as tall as possible in the first year, so that growth of the sub-apical buds in the second year results in lateral branches at the appropriate height. Where whips had exceeded 80 cm in the first year and were pruned back to 70 cm during the following winter, trees with a mean height of 119 cm were produced. These had an average of three lateral branches above the 60 cm mark from the ground. Work is continuing on techniques which induce useful laterals in those trees that only produced undersized whips in the first year.

In maidens produced during summer 1996 from an August 1995 budding, the benefit of retaining stock shoots during early summer 1996 was less marked than that in previous years. The main objective was to investigate the effect of removing the scion apex (leaving the last partially unrolled leaf) when the maiden tree had reached 70 cm in height. At the cost of approximately 15 cm (6") reduced height, tipping consistently increased the number of laterals produced 60 cm from the ground; this technique, combined with the preferred method of twice removing rootstock shoots in early summer, produced a greater number of first grade trees (64%) compared to removing rootstocks shoots only once (49%) or regularly removing them (28%). Even so, maiden tree quality both at East Malling and on commercial nurseries was lower in 1996 than in previous years, with tipped trees producing fewer laterals than non-tipped trees in earlier years. Data are currently being examined in an attempt to identify the cause of last year's inconsistency.

Selection of budsticks

In Queen Cox, and to a lesser extent Royal Gala, scion wood (budsticks) can vary considerably in their angle of shoot growth and their extent of defoliation by the time they are required for budding in mid-August. Results showed that shoot type from budsticks (vertical v horizontal) or partial defoliation of the bitstock had no effect on maiden height or lateral production in Queen Cox. Similarly, angle of shoot had no influence on subsequent growth in Royal Gala. Premature defoliation was not a problem with the latter cultivar.