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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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EAST MALLING RESEARCH

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Authentication

I declare this work was done under my supervision according to the procedures described herein and that this report is a true and accurate record of the results obtained.

.....G M Saunders Date .....

Report authorised by:

Dr Christopher Atkinson
Head of Science
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Signature ..... Date .....

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Grower Summary

Headline

- In pears, the dwarfing quince rootstock C132 shows great promise, whilst the Russian ‘Krymsk’ cherry rootstock LC-52 has performed exceptionally well.

Background and expected deliverables

The recent review of HDC-funded rootstock research projects (project TF 158) acknowledged that there is a strong need for new or improved rootstocks for apples, pears, plums and cherries that are dwarfing, precocious, high yielding and offer some measure of drought tolerance. The report recognised that rootstocks are a vital part of contemporary growing systems for tree fruits, but those currently employed have been used for decades and all have some limitations. Breeding programmes in the UK and abroad have generated a number of promising rootstocks in recent years, which are becoming increasingly available to growers. The report recommended that promising new rootstocks bred in the UK and overseas, should continue to be assessed in trials and that technology transfer should be improved.

Requirements for new apple rootstocks

The report emphasised the need for rootstocks with intermediate vigour between M.27 and M.9 and a replacement for M.26 that does not suffer from burr knotting and poor calcium uptake. Three new trials comprising eight rootstock selections in the required vigour range were planted in the spring of 2003 and 2004 as part of the previous HDC project (TF 134). The expectation was that the performance of these promising selections would be measured during the course of a subsequent project. The HDC Tree Fruit Panel agreed to support a further project, TF 172, which is reported here. Results of earlier screening trials have been published (Johnson *et al*., 2005) and four of the eight selections that were highlighted are included in the new trials at East Malling Research (EMR) and further selections are being built up in a commercial nursery prior to raising trees for future plantings.

Requirements for new pear rootstocks

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The report stressed the need for increased dwarfing of pear scions to fit them to high-density systems without the need to resort to the use of either plant growth regulating chemicals or root pruning. Although it was recognised that dwarfing quince rootstocks offer the best future for scions such as ‘Conference’ and ‘Comice’, most new pear varieties are incompatible with quinces and require the use of expensive interstocks. A fully dwarfing and easy to propagate *Pyrus* stock would be beneficial to provide a much wider range of graft compatibility with new pear varieties, as well as providing better tolerance of drought and alkaline soils. New dwarfing rootstocks that improve pear cropping precocity are vital if pears are to remain economically viable.

Requirements for new sweet cherry rootstocks

The report identified the major requirement for a rootstock that is more dwarfing than either ‘Gisela 5’ or ‘Tabel’ that would control the vigour of trees sufficiently for easy growth within tunnels. Ideally these dwarfing stocks would be easier to propagate than either ‘Tabel’ or ‘Gisela’ since this should allow the production of less expensive trees. Other requirements included dwarfing rootstocks that are more suited to heavy clay soils (‘Gisela’ clones perform poorly in wet soils) and for dwarfing stocks that induce large fruit size.

Requirements for new plum rootstocks

The report recognised that there is a major requirement to provide increased dwarfing for plum trees to facilitate production under high density systems and for rootstocks that induce precocity and consistently abundant yields of large, high quality fruits.

Overall objective

The primary objective of the project is to acquire new apple, pear, cherry and plum rootstocks from breeding programmes both at EMR and abroad. These will be evaluated and developed in UK growing conditions.

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Specific objectives

Apple

- To select and develop apple rootstocks with intermediate vigour between M.27 and M.9, which perform well in the nursery and which produce precocious and consistently abundant yields of high quality fruits of the desired marketable size grades.

- To select and develop a replacement rootstock in the M.26 vigour category, which does not suffer from burr knotting, poor calcium uptake or physiological disorders. This rootstock should also induce precocity and abundant yields of high quality fruits.

- To select and develop dwarfing rootstocks for apple which exhibit improved resistance to drought, weed competition, replant disease and soil borne diseases (e.g. collar/crown rot).

Pear

- To select and develop quince rootstocks which are more dwarfing than 'Quince C' and have improved precocity of cropping.

- To select dwarfing *Pyrus* rootstocks that are easy to propagate and that induce good yield precocity/productivity.

Cherry

- To select fully dwarfing rootstocks, more dwarfing then 'Gisela 5', that are easy to propagate and that induce good yield precocity, fruit size and sustained productivity.

Plum

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- To select dwarfing rootstocks from material available overseas that induce precocity and consistently high yields of large, high quality fruits.

Summary of the project and main conclusions

Apple rootstock trials planted at EMR

Trial description

There are currently five trials of apple rootstocks raised by breeders at EMR.

A trial was planted in spring 2003 (Plot EE 195) to evaluate new rootstocks from the breeding programme at EMR. Trees of 'Queen Cox' on three new rootstock selections (AR 486-1, AR 295-6 and AR 120-242) are being compared with M.9 and trees of 'Bramley's Seedling' on four new rootstock selections (AR 628-2, AR 69-7, AR 360-19 and AR 801-11) are being compared with M.27. These same rootstock selections are being compared in similar trials planted at the same time in the organic area (Plot GE 182) at EMR.

A further trial was planted in spring 2004 (Plot CE 190) to evaluate new rootstocks from the breeding programme at EMR. Trees of 'Cox La Vera' on two new rootstock selections (AR 801-11 and AR 680-2) are being compared with M.9.

Two further trial plots were planted in March 2010. Plot VF 224 is an organic plot comparing trees of Red Falstaff on AR 10-3-9, AR 809-3, AR 835-11, R 80, M.116 and MM.106. Plot EE 207 consists of 'Braeburn' and 'Royal Gala' each on AR 852-3, AR 839-9, B 24, M.26, M.27, M.9, R 104 and R 59.

Main conclusions to date

Under conventional production, neither of the rootstock selections in CE 190 ('Queen Cox') performed significantly differently to M.9. Similarly the selections in EE 195 ('Queen Cox') did not perform significantly differently to M.9 in respect of tree volume, yield or suckers. For organic production, the selection AR 120-242 (GE 182, 'Queen Cox') produced significantly higher yields (for 2009 and cumulative) than M.9, although yield efficiency was not significantly different. However, it is still too early to draw any conclusions from these trials.

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For ‘Bramley’, in both conventional and organic management, a range of vigour is being provided by new rootstock selections. ‘Bramley’ on AR 801-11 is the most vigorous and greater than on M.27, although yield efficiency is greater for M.27 than tested selections.

The extent of the general suppression of tree growth and cropping under organic management is shown in Table 1.

A new trial was planted in the organic area at EMR in the winter of 2009-10 using more invigorating rootstocks (MM.106/M.116 range) and a more appropriate scion cultivar (‘Red Falstaff’). New trials were planted in the conventional area using rootstocks in the M.26-M.27 range with ‘Braeburn’ and ‘Gala’.

Table 1. Growth and cropping in 2009 of ‘Queen Cox’ and ‘Bramley’s Seedling’ trees on a range of rootstocks from the EMR breeding programme planted in spring 2003. Figures presented are means of all rootstocks being tested.

	‘Queen Cox’		‘Bramley’s Seedling’	
	Conventional	**Organic**	**Conventional**	**Organic**
Girth (cm / tree)	12.2	9.9	11.4	10.3
Tree volume (m^3)	7.8	5.8	4.4	2.8
Yield (kg / tree)	8.6	3.2	6.4	1.4

Pear rootstock trials planted at EMR

Trial description

In a trial planted in 1999 (Plot PR 184) C132, a quince rootstock from the EMR breeding programme, which is slightly more dwarfing than ‘Quince C’ and possibly more winter hardy, was compared with ‘Quince C’ (EMC) and a promising Swedish *Pyrus* selection (BP 30).

Main conclusions to date

Yield from C132 was significantly greater than from EMC.

Pear rootstock trials planted on a commercial farm

Trial description

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An on-farm trial, managed by FAST Ltd, comparing the dwarfing quince rootstock C132 and 'Quince C' was planted at Robert Hinge's farm at Upchurch, in the winter of 2009-10.

Main conclusions to date

It is too early to draw any conclusions from this trial.

Cherry rootstock trials planted at EMR

Trial description

Three cherry rootstock trials are ongoing, using material raised at EMR and overseas. Two Russian (Krymsk) selections (LC-52 and VSL-2) are being compared with the cultivar 'Summersun' (Plot MP 177), planted in spring 2002. LC-52 is drought and cold tolerant and non-suckering. VSL-2 is similar in vigour to 'Gisela 5' and is precocious, non-suckering and can be propagated from cuttings. Another trial planted on plot MP 183 in spring 2005 is comparing four new selections from EMR with 'Tabel Edabriz' and 'Gisela 5' using the cultivar 'Sunburst'. A further trial was planted in the spring of 2006 to compare the performance of 'Gisela 3' with 'Gisela 5' using the cultivar 'Penny'. 'Gisela 3' is considered to be the more dwarfing stock and therefore more amenable to tunnel production.

Main conclusions to date

Russian 'Krymsk' rootstock LC-52 has produced significantly greater yields than VSL-2. LC-52 is more vigorous, higher yielding, has greater yield efficiency and produces fewer suckers than VSL-2. The EMR rootstock selection C113-3 on 'Sunburst' continues to be more dwarfing than 'Tabel Edabriz' but the yield so far has been poor in comparison. When comparing 'Gisela 3' and 'Gisela 5' using 'Penny', no significant differences in vigour or yield were found.

Plum rootstock trial planted on a commercial farm

The trial was brought to a premature end after the 2008 growing season.

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Financial benefits

The development of improved rootstocks will lead to a range of financial benefits.

Improved dwarfing can lead to reduced production and picking costs using trees that are better suited to modern production systems.

Improved precocity and yields will lead to higher returns per tree and per hectare of orchard.

Improved drought tolerance will lead to a reduction in irrigation water required and associated costs. It will also lead to a higher grade-out of class 1 fruit.

Action points

- This project is ongoing. At its conclusion, it is anticipated that new rootstocks will be recommended for use in commercial orchards.

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Science Section

Introduction

For the six years leading up to 31 March 2001 the selection, development and evaluation of new apple and pear rootstocks in the UK was funded by the East Malling Trust for Horticultural Research (EMTHR) with additional funding from the Apple and Pear Research Council (APRC). A report on the work carried out during that 6-year period was prepared by Dr Tony Webster and colleagues and submitted to APRC (SP 123) and the EMTHR in 2001. In 2001-02 the evaluation and development of new rootstocks for apples and pears was continued in a 1-year APRC project (SP 134) and a report on the work carried out from April 2001 until March 2002 was submitted to APRC in April 2002. Subsequently, the APRC agreed to continue project SP 134 for a further three years (March 2005) and they also decided to fund additional work (SP 141) to evaluate and develop in organic growing conditions new apple rootstocks produced by the breeding programme at EMR. From April 2003 to March 2005 these projects have been funded by the HDC (TF 134 and TF 141). In 2004 the HDC funded Dr David Pennell (then of ADAS) and Dr Tony Webster (consultant and formerly of HRI, East Malling) to carry out a review of HDC-funded rootstock research projects. The results of the review were not available in sufficient time for EMR to develop a new rootstock proposal before the 2005 growing season (Pennell, 2005). An interim proposal (TF 168) was prepared and accepted by HDC in order that the recording of existing trials could be continued. A report on the work carried out from April 2005 until March 2006 was submitted to the HDC in August 2006. During 2006 a new proposal for the evaluation and development of new rootstocks for apples, pears, cherries and plums was accepted by the HDC (TF 172). Funding is now secured until 2011/12 which will allow the introduction of new material from EMR and abroad and the testing of the most promising selections on growers farms.

Recent successes of the trialling programme include the release in 2001 of a new dwarfing quince rootstock for pears (EMH) and a new apple rootstock resistant to crown /collar rot (M116).

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Objectives

Apple

- To select and develop apple rootstocks with intermediate vigour between M.27 and M.9, which perform well in the nursery and which produce precocious and consistently abundant yields of high quality fruits of the marketable size grades
- To select and develop a replacement rootstock in the M.26 vigour category, which does not suffer from burr knotting, poor calcium uptake or physiological disorders. This rootstock should also induce precocious and abundant yields of high quality fruits
- To select and develop dwarfing rootstocks for apple which exhibit improved resistance to drought, (weed competition) replant disease and soil borne diseases (e.g. collar/crown rot)

Pear

- To select and develop quince rootstocks more dwarfing than 'Quince C'' with improved precocity of cropping
- To select dwarfing *Pyrus* rootstocks that are easy to propagate, and that induce good yield precocity/productivity

Cherry

- To select fully dwarfing rootstocks, more dwarfing then 'Gisela 5', that are easy to propagate and that induce good yield precocity, fruit size and sustained productivity

Plum

- To select from material available overseas dwarfing rootstocks that induce precocious and consistently abundant yields of large good quality fruits

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Apple rootstock trials planted at EMR

Currently there are five trials of apple rootstocks raised and planted at EMR.

A trial was planted on 8 May 2003 (Plot EE 195) to evaluate new rootstocks from the breeding programme at EMR. Using 'Queen Cox' three new rootstock selections (AR 486-1, AR 295-6 and AR 120-242) are being compared with M.9 and using 'Bramley's Seedling' four new rootstock selections (AR 628-2, AR 69-7, AR 360-19 and AR 801-11) are being compared with M.27. These same rootstock selections are being compared in similar trials planted at the same time in the organic area (Plot GE 182) at EMR.

A trial was planted on 18 May 2004 (Plot CE 190) to evaluate new rootstocks from the breeding programme at EMR. Using 'Cox La Vera' two new rootstock selections (AR 801-11 and AR 680-2) are being compared with M9.

A trial planted on 15 March 2010 (Plot VF 224) compares trees of 'Red Falstaff' on AR 10-3-9, AR 809-3, AR 835-11, R 80, M 116 and MM106 when grown organically.

Another planting (Plot EE207) was planted on 16 March 2010 and consists of 'Braeburn' and 'Royal Gala' each on AR 852-3, AR 839-9, B 24, M.26, M.27, M.9, R 104 and R 59.

Pear rootstock trials planted at EMR

In a trial planted in 1999 (Plot PR 184) C 132, a quince rootstock from the EMR breeding programme, which is slightly more dwarfing than 'Quince C' and possibly more winter hardy, is being compared with 'Quince C' (EMC) and a promising Swedish *Pyrus* selection (BP 30).

Pear rootstock trials planted on a commercial farm

An on-farm trial, managed by FAST Ltd, comparing the dwarfing quince rootstock C132 and 'Quince C' was planted at Robert Hinge's farm at Upchurch in the winter of 2009-10.

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Cherry rootstock trials planted at EMR

There are currently three trials of cherry rootstocks raised by breeders at EMR and abroad. These include a comparison of two Russian (Krymsk) selections (LC-52 and VSL-2) using the cultivar 'Summersun' (plot MP 177) planted in spring 2002. LC-52 is drought and cold tolerant and non-suckering. VSL-2 is similar in vigour to 'Gisela 5' and is precocious, non-suckering and can be propagated from cuttings. Four new selections from EMR are being compared with 'Tabel Edabriz' and 'Gisela 5' using the cultivar 'Sunburst'. This trial was planted on plot MP 183 in spring 2005. The latest trial was planted in the spring of 2006 and will compare the performance of 'Gisela 3' with 'Gisela 5' using the cultivar 'Penny'. 'Gisela 3' is considered to be the more dwarfing stock and therefore more amenable to tunnel production.

Plum rootstock trial planted on a commercial farm

The trial was brought to a premature end after the 2008 growing season. No firm conclusions were made due to the lack of crop in previous years due to frost and hail. The grower hosting the trial required the land for other purposes and the trees were grubbed in the winter of 2008/09.

Materials and Methods

In all of the EMR trials, the tree rows were maintained weed free using conventional herbicides (excluding the organic trial on Plot GE 182) and the alleys between the rows were grassed down and maintained by frequent mowing. No supplementary irrigation was supplied to the trees. Minimal pruning was undertaken in the first few years following planting; the trees were, however, headed when necessary to encourage the production of lateral branches, but no branch tipping was undertaken. Where appropriate, very upright branches were tied down towards the horizontal and a modified form of 'long spur pruning' employed. No chemical growth regulators or root pruning techniques have been used to supplement growth control in any of the trials reported on.

Measurements were taken of trunk girth 25 cm above ground level for cherry, 45 cm above ground level for plum and 15 cm above ground level for apple and pear.

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Where appropriate, numbers and lengths of shoots or heights and spreads of the tree crowns (apple and pear) were recorded along with fresh weights at the time of grubbing. Total yields and yields of class one fruit >65 mm (or >80 mm for 'Bramley' and >55 mm for 'Conference') were measured for each tree and cumulative yields and yield efficiencies were calculated. Average fruit weights were calculated for cherry and plum. In the cherry and plum trials the numbers of suckers per tree were recorded. In all trials notes on tree health, graft compatibility and anchorage were made as required.

Results and Discussion

Performance of Queen Cox on new East Malling Research rootstock selections

Under conventional management

Selections AR 801-11 and AR 680-2 (Plot CE 190) (Tables 1 and 2)

In 2008 the vigour (trunk girth and tree volume) of AR 680-2 and AR 801-11 was similar to M.9 but both rootstock selections had a reduced yield compared with M.9. In 2009 the vigour appeared greater for AR 60-2 and less for AR 801-11 compared with M.9, but neither was statistically significant (Table 1). Yield efficiency in 2009 was not significantly better for the AR selections compared to M.9 (Table 2). The trial is planned to continue until 2012.

Table 1. Growth and cropping in 2009 of 'Queen Cox' trees (Plot CE190) on rootstocks from the East Malling breeding programme planted in spring 2004

Rootstock	Girth 2009 (cm / tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Yield Class 1 >65 mm 2009 (kg / tree)	Suckers 2009 (No. / tree)
AR680-2	11.3	6.3	10.8	3.1	2.4
AR801-11	10.1	3.7	8.1	1.1	2.3
M9	11.7	5.4	6.0	1.9	2.0
SED (30 df)	0.76	1.12	2.16	0.86	0.66
LSD (P=0.05)	1.56	2.28	4.41	1.76	1.34
Rootstock effect	n.s.	n.s.	n.s.	n.s.	n.s.

Note: (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability)

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Table 2. Cumulative yield and yield efficiency of 'Queen Cox' trees (Plot CE 190) on rootstocks from the East Malling Research breeding programme planted in spring 2004

Rootstock	Cumulative yield 2004-09 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >65 mm	
AR 680-2	21.3	10.7	2.07
AR 801-11	17.6	7.5	2.20
M.9	22.2	10.5	2.05
SED (28df)	3.40	2.49	0.241
LSD (P=0.05)	6.95	5.11	0.494
Rootstock effect	n.s.	n.s.	n.s.

Note: (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability)

Performance of Queen Cox on new East Malling Research rootstock selections

Under conventional management

Selections AR 486-1, AR 295-6 and AR 120-242 (Plot EE 195) (Tables 3 and 4)

At the time of planting (8 May 2003) there were only sufficient grafted 2-year-old trees of AR 295-6 and AR 120-242 to complete blocks 4 and 5 of the eight blocks respectively. The remaining blocks were completed using budded 1-year-old trees. The analysis of the data up to 2008 was necessarily restricted to the four complete blocks of grafted trees. It is anticipated that as the trees get older any potential differences between the budded and grafted trees will diminish and it will be appropriate to use all eight replicate trees in the statistical analysis.

In 2009 there were no significant differences in tree volume or yield for either: AR 486-1, AR 295-6 or AR 120-242 compared to M.9 (Table 3). However, AR 120-242 has significantly larger girth that M9.

AR 486-1 had a significantly lower total cumulative yield and yield efficiency than M.9 Table 4). Cumulative total yields were not significantly different for AR 295-6 and AR 120-242 compared to M.9 and neither was the yield efficiency for AR 295-6, however the yield efficiency was significantly lower for AR 120-242 than for M9.

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Table 3. Growth and cropping in 2009 of' Queen Cox' trees (EE 195) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Girth 2009 (cm/tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Yield Class 1 >65 mm 2009 (kg/tree)	Suckers 2009 (No./tree)
M.9	11.9	7.4	10.3	0.0	2.0
AR 486-1	11.3	7.0	4.7	2.6	1.0
AR 295-6	11.2	8.5	9.6	2.7	0.5
AR 120-242	14.6	8.1	9.9	3.2	0.0
SED (9 df)	0.59	1.57	2.98	1.05	0.76
LSD (P=0.05)	1.32	3.56	6.75	2.39	1.71
Rootstock effect	***	n.s.	n.s.	n.s.	n.s.

Note: Data presented for blocks 1-IV only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Table 4. Cumulative yield and yield efficiency of 'Queen Cox' trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Cumulative yield 2004-09 (kg/tree)		Yield efficiency (kg/cm^2)
	Total	Class 1 >65 mm	
M.9	47.3	15.2	4.22
AR 486-1	30.2	10.5	3.02
AR 295-6	42.1	19.0	4.22
AR 120-242	49.8	23.4	2.98
SED (9 df)	5.19	2.76	0.449
LSD (P=0.05)	11.74	6.24	1.015
Rootstock effect	*	**	*

Note: Data presented for blocks I-IV only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Performance of 'Queen Cox' on new East Malling Research rootstock selections

Under organic management

Selections AR 486-1, AR 295-6 and 120-242 (Plot GE 182) (Tables 5 and 6)

There were only sufficient grafted 2-year-old trees of AR 295-6 to complete four of the eight blocks respectively. The remaining blocks were completed using budded 1-year-old trees. In order to compare all rootstocks the analysis of the growth data was

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necessarily restricted to the four complete blocks of grafted trees. It is anticipated that as the trees get older any potential differences between the budded and grafted trees will diminish and it will be appropriate to use all 8 replicate trees in the statistical analysis. To compare only AR 486-1, AR 120-242 and M9 the data can be restricted so that the data for all eight blocks are used.

In 2009 the only significant rootstock effect was on total fruit yield with AR 120-242 having the greatest yield (Table 5). There were no significant differences in tree girth, tree volume or yield of class I fruit. AR 120-242 also had a significantly greater total and class I cumulative yield than M.9, although yield efficiency was not significantly different from M.9.

As noted in previous reports for TF 172 there was a major impact of the production system on tree performance. Average tree volume and trunk girth were reduced by 25 and 19% respectively through the adoption of organic management. More importantly the yield of trees under organic management was only 17% of that achieved under conventional management. The trial is planned to continue until 2011.

Table 5. Growth in 2009 of 'Queen Cox' trees (Plot GE182) on rootstocks from the East Malling Research breeding programme planted in spring 2003 and managed under organic conditions

Rootstock	Girth 2009 (cm / tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Yield Class 1 >65 mm 2009 (kg / tree)	Suckers 2009 (No. / tree)
M9	9.9	5.6	0.9	0.4	0.0
AR 486-1	9.5	4.5	4.1	1.5	0.7
AR 295-6	9.1	5.9	1.8	0.7	0.0
AR 120-242	11.2	7.2	6.1	1.7	0.0
SED (8 df)	0.83	1.13	1.41	0.58	-
LSD (P=0.05)	1.92	2.61	3.24	1.33	-
Rootstock effect	n.s.	n.s.	*	n.s.	-

Note: - insufficient data to allow statistical analysis. Data presented for blocks 1-IV only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

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Table 6. Cumulative yield and yield efficiency of 'Queen Cox' trees (Plot GE182) on rootstocks from the East Malling Research breeding programme planted in spring 2003

Rootstock	Cumulative yield 2004-09 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >65 mm	
M9	6.8	1.1	0.86
AR 486-1	6.6	1.7	0.96
AR 295-6	5.6	1.2	0.86
AR 120-242	11.4	3.2	1.20
SED (8 df)	1.76	0.62	0.271
LSD (P=0.05)	4.06	1.42	0.625
Rootstock effect	*	*	n.s.

Note: Data presented for blocks 1-IV only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Performance of 'Bramley's Seedling' on new East Malling Research rootstock selections

Under conventional management

Selections AR 628-1, AR 69-7, AR 360-19 and AR 801-11 (Plot EE 195) (Tables 7 and 8)

The design of the trial on EE 195 was complicated by insufficient numbers of grafted trees for AR 360-19 and AR 801-11 to complete eight blocks as planned. There were sufficient trees for five blocks of these rootstocks and eight blocks of AR 628-2, AR 69-7 and M.27 controls. Additional trees on AR 628-2, AR 69-7 were used to complete the blocks.

The analysis of the data was necessarily restricted to the five complete blocks of grafted trees. In addition the trees with eight replicates (AR 628-2, AR 69-7 and M27) were analysed separately.

It is expected that the new rootstock selections will confer tree sizes in the M.27-M.9 range with the exception of AR 801-11 which should have a vigour status closer to M26. It is anticipated that as the trees get older any potential differences due to tree age at planting will diminish. Clearly it will take a number of growing seasons for the trees to establish and produce significant quantities of fruit.

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AR 360-19 and AR 69-7 were not significantly different than M.27 for any of the assessments (Table 7). Cumulative and 2009 yields both total and class I, for AR 628-2 were significantly less than for M.27 (Table 8). AR 801-11 produced cumulative and 2009 yields; both total and Class 1, which were significantly greater than those of M.27. The trial is planned to continue until 2011.

Table 7. Growth and cropping in 2009 of 'Bramley's Seedling' trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Girth 2009 (cm / tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Yield Class 1 >80 mm 2009 (kg / tree)	Suckers 2009 (No. / tree)
M27	11.0	3.9	6.4	1.9	1.0
AR 360-19	10.5	3.3	4.7	0.4	1.0
AR 69-7	11.2	3.1	3.7	0.9	0.0
AR 628-2	7.7	0.6	1.1	0.0	0.0
AR 801-11	16.5	11.3	16.3	2.9	0.4
SED (16 df)	0.86	1.11	3.68	0.86	0.50
LSD (P=0.05)	1.82	2.34	7.80	1.83	1.07
Rootstock effect	***	***	**	*	n.s.

Note: Data presented for blocks I-V only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Table 8. Cumulative yield and yield efficiency of Bramley's Seedling trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Cumulative yield 2004-09 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >80 mm	
M27	21.1	12.0	2.16
AR 360-19	18.2	8.8	2.13
AR 69-7	16.2	6.7	1.56
AR 628-2	4.8	0.0	1.11
AR 801-11	43.5	22.6	1.96
SED (16 df)	4.96	2.75	0.320
LSD (P=0.05)	10.71	5.94	0.692
Rootstock effect	***	***	*

Note: Data presented for blocks I-V only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Under organic management

Selections AR 628-1, AR 69-7, AR 360-19 and AR 801-11(Plot GE182) (Tables 9 and 10)

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The constraints on the design of the orchard under conventional management imposed by lack of sufficient grafted trees (see above) applied also to the orchard planted in the organic area at East Malling Research.

Although yield was not significantly different, girth and tree volume were both significantly greater for AR 801-11 compared to M.27 (Table 9). The tree volume of AR 69-7 was significantly greater than that of M.27 but no other parameters for AR 69-7, AR 628-1 or AR 360-19 were significantly different to those of M.27.

It should be borne in mind that any differences in girth measurements may reflect the fact that the control (M27) trees were one year old when planted and were obtained from a different UK nursery to the 2-year-old trees on the experimental rootstocks. However it is expected that these rootstocks are likely to provide tree sizes in the M.27-M.9 range with the exception of AR 801-11 which should have a vigour status closer to M.26. It is anticipated that as the trees get older any potential differences due to tree age at planting will diminish.

Table 9. Growth and cropping in 2009 of 'Bramley's Seedling' trees (Plot GE 182) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Girth 2009 (cm / tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Yield Class 1 >80 mm 2009 (kg / tree)	Suckers 2009 (No. / tree)
M27	8.8	1.8	0.5	0.1	0.0
AR 360-19	8.1	1.0	0.9	0.2	0.2
AR 69-7	11.5	4.2	2.9	1.9	0.0
AR 628-2	7.1	0.4	0.9	0.0	0.2
AR 801-11	15.8	6.5	1.9	0.5	0.0
SED (16 df)	1.36	1.07	1.19	0.68	-
LSD (P=0.05)	2.89	2.27	2.51	1.45	-
Rootstock effect	***	***	n.s.	n.s.	-

Note: - insufficient data to allow statistical analysis. Data presented for blocks 1-V only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

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Table 10. Cumulative yield and yield efficiency of 'Bramley's Seedling' trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003

Rootstock	Cumulative yield 2004-09 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >80 mm	
M.27	3.9	0.5	0.72
AR 360-19	2.5	0.5	0.44
AR 69-7	5.4	2.2	0.55
AR 628-2	1.8	0.0	0.47
AR 801-11	5.9	1.4	0.31
SED (16 df)	1.49	0.81	0.183
LSD (P=0.05)	3.15	1.72	0.387
Rootstock effect	n.s.	n.s.	n.s.

Note: Data presented for blocks 1-V only (see text). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Overall there was a major impact of the production system on tree performance. Average tree volume and trunk girth were reduced by 37 and 10% respectively through the adoption of organic management (Table 9). More importantly the yield of trees under organic management was reduced by 78% compared to the average yield achieved under conventional management (Table 10). The trial is planned to continue until 2011.

Performance of 'Comice' and 'Conference' on Quince (EMC and C 132) and Pyrus (BP 30) rootstocks

The trees on PR 184 were budded at a height of 10 and 25 cm. Previous work (see final report for APRC on SP 123) had shown that increasing the height of budding on 'Comice' reduced the vigour of trees on EMC rootstock (Table 11).

Girth was significantly smaller for the 10 cm budded trees than the 25 cm budded trees for BP 30, whereas girth was significantly greater for the 10 cm budded trees than the 25 cm budded trees for C 132 (Table 12).

BP 30 produced a significantly lower cumulation yield for both bud heights for both 'Comice' and 'Conference' using EMC.

2009 yields (total and > 65 mm) for both 'Comice' and 'Conference' were significantly higher for C 132 than for EMC.

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Table 11. Cropping in 2009 of 'Comice' and 'Conference' trees on Quince (EMC and C 132) and *Pyrus* (BP 30) rootstocks planted spring 1999 (Plot PR 184)

Cultivar	Rootstock	Graft height (cm)	Total yield (kg/tree)		Yield Class 1 >65 mm (kg/tree)	
			2009	Cumulative	2009	Cumulative
Comice	EMC	10	11.7	80.9	5.6	60.8
	EMC	25	12.2	87.2	5.7	62.9
	BP 30	10	9.9	64.9	4.6	46.3
	BP 30	25	11.1	72.8	5.5	57.2
	C 132	10	17.3	92.3	8.6	78.6
	C 132	25	14.5	88.2	8.0	74.8
Conference	EMC	10	11.3	57.7	0.0	5.4
	EMC	25	11.3	62.1	0.0	4.7
	BP 30	10	9.4	49.4	0.0	7.6
	BP 30	25	10.0	57.2	0.0	6.4
	C 132	10	14.9	62.4	0.2	10.0
	C 132	25	13.3	64.9	0.4	13.0
Overall effect	EMC		11.7	72.0	2.8	33.4
	BP 30		10.1	61.1	2.5	29.4
	C 132		15.0	76.9	4.3	44.1
SED (89 df)			0.82	3.91	0.55	2.76
LSD (P=0.05)			1.63	7.76	1.08	5.48
Rootstock effect			***	***	**	***

Note: SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability.

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Table 12. Growth in 2009 of 'Comice' and 'Conference' trees on Quince (EMC and C 132) and *Pyrus* (BP 30) rootstocks planted spring 1999 (Plot PR 184)

Variety	Rootstock	Graft height (cm)	Girth 2009 (cm / tree)	Tree Volume 2009 (m^3)	Yield efficiency (kg / cm^2)
Comice	EMC	10	24.6	-	1.66
	EMC	25	22.5	-	2.18
	BP30	10	21.8	-	1.75
	BP30	25	23.1	-	1.75
	C132	10	27.3	-	1.63
	C132	25	24.0	-	1.94
Conference	EMC	10	17.8	-	2.31
	EMC	25	16.6	-	2.82
	BP30	10	16.4	-	2.22
	BP30	25	19.2	-	1.96
	C132	10	20.3	-	1.90
	C132	25	17.3	-	2.71
Overall effect	EMC		20.4	-	2.24
	BP30		20.1	-	1.92
	C132		22.2	-	2.04
SED (89 df)			0.60		0.098
LSD (P=0.05)			1.19		0.195
Rootstock effect			**		**

Note: - No data available for 2009 tree volume. (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Cherry rootstock trials at EMR

Russian ('Krymsk') rootstock trial (Plot MP 177)

2009 was a good cropping year for cherries with good yields achieved compared to 2008. Yield, mean fruit weight, yield efficiency and tree volume were significantly

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greater for LC 52 than VSL 2 (Table 13). LC 52 produced significantly fewer suckers than VSL 2.

Table 13. The effect of rootstock on the growth and cropping of 'Summersun' cherry trees in 2009. Trees planted on plot MP177 at EMR on 18 April 2002

Rootstock	2009 data					Cumulative data (2003-2009)	
	Girth (cm)	Tree Volume (m^3)	Total Yield (kg)	Mean Fruit Weight (g)	Suckers (No./tree)	Total Yield (kg/tree)	Yield efficiency (kg/cm^2)
LC 52	38.3	46.2	19.9	9.2	0.6	66.0	0.57
VS L2	33.2	36.5	10.5	8.6	2.5	41.7	0.48
SED (17 df)	1.47	3.03	2.26	0.19	0.55	3.90	0.022
LSD (P=0.05)	3.11	6.39	4.78	0.40	1.17	8.23	0.046
Effect of Rootstock	**	**	***	**	**	***	***

Note: SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

'Gisela 3' and '5' comparison (Plot MP 186)

Differences between Gisela 3 and Gisela 5 rootstocks were not significant, however Gisela 3 appeared less vigorous than Gisela 5 (Table 14). The trial is planned to continue until 2013.

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Table 14. The effect of Gisela rootstocks on the growth and cropping of 'Penny' cherry trees in 2009. Trees planted on plot MP186 at EMR in March 2006

Rootstock	2009 data					Cumulative data (2007-2009)	
	Girth (cm)	Tree Volume (m^3)	Total Yield (kg)	Mean Fruit Weight (g)	Suckers (No./tree)	Total Yield (kg/tree)	Yield efficiency (kg/cm^2)
Gisela 3	18.9	14.0	3.9	13.9	0	4.3	0.16
Gisela 5	19.7	17.9	3.8	13.4	0	4.3	0.14
SED (7 df)	1.04	2.42	1.21	0.24	-	1.52	0.066
LSD (P=0.05)	2.47	5.72	2.85	0.61	-	4.22	0.182
Effect of Rootstock	n.s.	n.s.	n.s.	n.s.	-	n.s.	n.s.

Note: EMR rootstock selections tested on 'Sunburst' (Plot MP 182) (Table 15). (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

There were no significant differences in yield between the assessed rootstocks (Table 15). C376-1 has the greatest tree volume, greater than Gisela 5 and C 113-3 has the smallest tree volume, smaller than Tabel Edabriz.

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Table 15. The effect of EMR rootstock selections on the growth and cropping of 'Sunburst' cherry trees in 2009. Trees planted on plot MP 182 at EMR in April 2005

Rootstock	Girth 2009 (cm/tree)	Tree Volume 2009 (m^3)	Yield 2009 (kg/tree)	Mean fruit weight 2009 (g)	Suckers 2009 (No./tree)
C113-3	16.2	11.3	1.4	9.8	0.3
C376-1	23.3	25.8	4.6	12.6	0.6
C376-4	21.7	18.7	3.6	11.8	1.0
C376-5	20.5	17.8	3.8	12.0	0.6
Tabel Edabriz	19.2	12.2	3.8	8.3	0.0
Gisela 5	19.2	23.1	5.0	11.3	0.5
SED (16 df)	2.02	4.78	2.09	0.83	0.83
LSD (P=0.05)	4.29	10.13	4.43	1.79	1.75
Effect of Rootstock	**	*	n.s.	***	n.s.

Note: (SED–Standard Error of the Difference between means, LSD–Least Significant Difference between means, df–degrees of freedom, rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

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Conclusions

Apple rootstock trials planted at EMR

Under conventional production, neither of the rootstock selections AR 680-2 and AR 801-11 in CE 190 ('Queen Cox') performed significantly differently to M.9. Neither did the rootstocks AR 486-1, AR 295-6 and 120-242 (EE 195, 'Queen Cox') perform significantly differently to M.9 in respect to tree volume, yield or suckers. For organic production, AR 120-242 (GE 182, 'Queen Cox') had significantly greater yields (for 2009 and cumulative) than M.9 although yield efficiency was not significantly different. It is still however too early to make any commercially relevant conclusions from these trials.

For 'Bramley', in both conventional and organic management, a range of vigour is being provided by new rootstock selections. 'Bramley' on AR 801-11 is the most vigorous and of greater vigour than on M.27, although yield efficiency is greater for M.27 than the tested selections.

Pear rootstock trials planted at EMR

Yield from C132 was significantly greater than from EMC.

Pear rootstock trials planted at on a commercial farm

C132 and EMC will undergo final evaluation in on-farm trials established by FAST Ltd during the winter of 2009/10.

Cherry rootstock trials planted at EMR

The Russian 'Krymsk' rootstock LC-52 has produced significantly greater yields than VSL 2. LC 52 continues to be more vigorous and higher yielding than VSL 2 and is more yield efficient and produces fewer suckers. The EMR rootstock selection C113-3 on 'Sunburst' continues to be more dwarfing than 'Tabel Edabriz', but the yield so far has been poor in comparison. Comparing 'Gisela 3' and 'Gisela 5' worked with the cultivar 'Penny' there were no significant differences for vigour or yield.

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Technology Transfer

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