Project title:	Evaluation and development of new rootstocks for apples, pears, cherries and plums
Project number:	TF172
Project leader:	Gary Saunders
Report:	Final report, 31 August 2012
Previous report:	Annual report, 31 March 2012
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Location of project:	East Malling Research
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Date project commenced:	01 April 2002
Date project completed (or expected completion date):	31 March 2012

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AUTHENTICATION

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

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24 August 2012

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GROWER SUMMARY

Headline

A new EMR apple rootstock AR296-6 (slightly less vigorous than M9 but with better yield efficiency and anchorage) has performed well in these trials and is now being propagated by European nurserymen.

Background and expected deliverables

The review of HDC-funded rootstock research projects (project TF158, 2004) highlighted 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 current growing systems, but those currently used in tree fruit production have been grown 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 UK trialling of promising UK and overseas material should continue and that technology transfer should be improved.

Requirements in new apple rootstocks

The report emphasised the need for apple rootstocks with intermediate vigour between M27 and M9 and a replacement for M26 that does not suffer from burr knotting and poor calcium uptake. Fortuitously three new trials comprising eight rootstock selections in the required vigour range were planted in spring 2003 and 2004 as part of the previous HDC rootstock project (TF134). The performance of these promising selections have been measured during the course of this project. 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 EMR and further selections are being propagated in a commercial nursery prior to raising trees for future plantings.

Requirements in new pear rootstocks

The report stressed the need for increased dwarfing of pear scions to fit them to high-density systems without the need to resort to use of either plant growth regulating chemicals or root pruning. Although it was recognised that dwarfing quince rootstocks are the best way forward 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

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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 in 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 were for 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 in 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 precocious and consistently abundant yields of large good quality fruits.

Overall objective

The main aim of the project was to acquire, evaluate and develop in UK growing conditions new apple, pear, cherry and plum rootstocks produced by breeding programmes both at EMR and abroad.

Specific objectives

Apple

- To select and develop apple rootstocks with intermediate vigour between M27 and M9, 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 M26 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).

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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 dwarfing rootstocks from material available overseas, that induce precocious and consistently high yields of large good quality fruits.

Summary of the project and main conclusions

Apple rootstock trials planted at EMR

Trial descriptions

Five trials of apple rootstocks raised by breeders at EMR were planted.

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) were compared with M9 and trees of 'Bramley's Seedling' on four new rootstock selections (AR 628-2, AR 69-7, AR 360-19 and AR 801-11) were compared with M27. These same rootstock selections were compared in similar trials planted at the same time in the organic area (Plot GE 182) at EMR.

This was followed by a trial 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) were compared with M9.

Two further trial plots were planted in March 2010. Plot VF 224 was an organic plot comparing trees of Red Falstaff on AR10-3-9, AR809-3, AR835-11, R80, M116 and MM106. Plot EE207 consisted of Braeburn and Royal Gala each on AR852-3, AR839-9, B24, M26, M27, M9, R104 and R59.

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Main conclusions

Under conventional production, neither of the rootstock selections in CE190 (Cox La Vera) performed consistently significantly differently to M9 in respect to girth, tree volume, yield, number of suckers, cumulative yield or yield efficiency. Neither did the selections in EE195 (Queen Cox) perform consistently significantly differently to M9 in respect to tree volume, yield or class I yield. For organic production, (GE182, Queen Cox) selections did not have significantly different yields or yield efficiency (for 2011 and cumulative) from M9. However, one selection, AR295-6 has shown promise throughout the trial, similar in vigour to M9 and equal to or greater yield efficiencies over the course of the trial. This selection is now undergoing commercial propagation for release to industry and US patent and Plant Breeders Rights will be applied for.

For Bramley, in both conventional and organic management, a range of vigour is being provided by new rootstock selections. Bramley on AR801-11 is the most vigorous and greater than on M27 but yield efficiency is not significantly different between M27 and the tested selections.

Although only planted in the winter of 2009-10, Braeburn on R59 so far has less vigour than M26 and similar vigour to M9 with a higher yield than M26 and a similar yield to M9. Royal Gala on R59 so far has less vigour than M26 and M9 with a higher yield.

In the Red Falstaff trial no significant differences in vigour or yield were evident.

Pear rootstock trials planted at EMR

Trial descriptions

In a trial planted in 1999 (Plot PR 184) C132, a quince rootstock from the EMR breeding programme, which was reputed to be more dwarfing than 'Quince C' and possibly more winter hardy, was compared with 'Quince C' (EMC) and a promising Swedish *Pyrus* selection (BP30).

Main conclusions

The quince rootstock C132 has given contradictory results in two plots planted at EMR. In the last plot to be grubbed, C132 showed greater or equal vigour to Quince C for Conference (variability depending on graft height) but no significant differences in yield efficiency. BP30 initially appeared slightly more vigorous than Quince C but with similar

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cumulative yield. Results at the end of the trial show BP30 to be less vigorous than Quince C but with similar cumulative yield and greater yield of Class I fruit.

Pear rootstock trials planted on a commercial farm

Trial descriptions

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. No fruit has yet been produced and it is now believed that the C132 material used in this trial is not true to type.

Main conclusions

It is not possible to draw any conclusions from this trial.

Cherry rootstock trials planted at EMR

Trial descriptions

There were three trials of cherry rootstocks raised at EMR and abroad. These included a comparison of two Russian (Krymsk) selections (LC-52 and VSL-2) using the cultivar 'Summersun' (plot MP 177) planted 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. In a second trial, four new selections from EMR were compared with 'Tabel Edabriz' and 'Gisela 5' using the cultivar 'Sunburst'. This trial was planted on plot MP183 in spring 2005. The latest trial was planted in the spring of 2006 and compared 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

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. On this plot 'Gisela 5' is clearly the most productive rootstock. Comparing 'Gisela 3' and 'Gisela 5' worked with the cultivar 'Penny', there have been no significant differences for vigour or yield as yet.

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Plum rootstock trial planted on a commercial farm

The trial was brought to a premature end after the 2008 growing season after environmental factors had caused successive low yields / crop failure.

Overall conclusions

Apple:

- A successful selection from the programme has been made, AR295-6, (slightly less vigorous than M9 but with better yield efficiency and anchorage) which is now being propagated by European nurserymen. High health status mother trees will be planted spring 2013, US patent will be applied for in 2013 and EU Plant Breeders Rights in 2013/2014.

Pear:

- C132 is not a suitable replacement for Quince C.
- BP30 is a potential rootstock where *Pyrus* rootstocks are preferred to quince.

Cherry:

- Gisela 5 is the most suitable rootstock for UK cherry production being reasonably dwarf with a high yield efficiency.

Plum:

- No definite conclusions could be drawn from the project.

Financial benefits

Although no specific cost/benefit analysis was carried out for this project, there are major financial implications of identifying rootstocks with improved agronomic performance and that satisfy consumer requirements in terms of fruit size and quality.

Action points for growers

- Continued evaluation of rootstocks is required to keep up with the changes in scion varieties, growing systems and UK climate to find optimum rootstocks for the UK.

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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) in 2000-01. A report on the work (originally SP 123 and coded TF 123 by HDC since April 2003 when HDC took over responsibility for APRC functions) carried out during that 6-year period was prepared by Dr. Tony Webster and colleagues and submitted to the Apple and Pear Research Council (APRC) and the East Malling Trust for Horticultural Research (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 (originally SP 134 then re-coded TF 134 in 2003) 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 (originally SP 141 and now coded TF 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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The project had the following objectives:

Apple

- To select and develop apple rootstocks with intermediate vigour between M27 and M9, 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 M26 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

In the last two years of the trial, five apple, two pear and three cherry rootstock plots have been evaluated. These consisted of:

Apple

Plot EE 195 - A trial planted on 8 May 2003 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) were compared with M9 and using 'Bramley's Seedling' four new rootstock selections (AR 628-2, AR 69-7, AR 360-19 and AR 801-11) were compared with M27.

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Plot GE 182 - A trial planted on 8 May 2003 using the same rootstock selections as EE 195 but grown under organic conditions at EMR.

Plot CE 190 - A trial planted on 18 May 2004 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) were compared with M9.

Plot VF 224 - A trial planted on 15 March 2010 comparing trees of Red Falstaff on AR10-3-9, AR809-3, AR835-11, R80, M116 and MM106 when grown organically.

Plot EE 207 - This was planted on 16 March 2010 and consists of Braeburn and Royal Gala each on AR852-3, AR839-9, B24, M26, M27, M9, R104 and R59.

Pear

Plot PR 184 - In a trial planted in 1999, 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 (BP30).

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.

Cherry

Plot MP177 - This trial consisted of a comparison of two Russian (Krymsk) selections (LC-52 and VSL-2) using the cultivar 'Summersun' 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.

Plot MP 183 - Four new selections from EMR were compared with 'Tabel Edabriz' and 'Gisela 5' using the cultivar 'Sunburst'. This trial was planted in spring 2005.

Plot MP 186 - The latest trial was planted in the spring of 2006 and compared 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.

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The on-farm plum rootstock trial was brought to a premature end after the 2008 growing season as the grower hosting the trial required the land for other purposes and the trees were grubbed in the winter of 2008/9.

Materials and methods

In all of the EMR trials, the tree rows were maintained weed free using conventional herbicides (excluding the organic trials on plots GE 182 and VF 224) 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. 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 I 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

Performance of Queen Cox on new East Malling rootstock selections

Under conventional management

Selections AR 801-11 and 680-2 (Plot CE190)

In 2010 M9 produced a significantly greater yield than AR680-2 and AR801-11. AR801-11 produced significantly lower values for tree volume, class 1 >65 mm and total cumulative yield when compared to M9. However in 2011 AR680-2 produced a greater yield of class I fruit than AR801-11 or M9 but cumulative yields and yield efficiency showed no differences between treatments.

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Table 1. Growth and cropping in 2010 of Queen Cox trees (Plot CE190) on rootstocks from the East Malling breeding programme planted in spring 2004. (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).

Rootstock	Girth 2010 (cm / tree)	Tree Volume 2010 (m^3)	Yield 2010 (kg/tree)	Yield Class 1 >65 mm 2010 (kg / tree)	Suckers 2010 (No. / tree)
AR801-11	11.2	4.7	6.6	1.3	2.3
AR680-2	13.0	7.2	6.6	3.0	2.6
M9	12.8	8.7	15.0	4.8	1.8
SED (30 df)	0.83	1.60	3.54	1.48	0.68
LSD (P=0.05)	1.69	3.27	7.22	3.02	1.38
Rootstock effect	ns	*	*	*	ns

Table 2. Cumulative yield and yield efficiency of Queen Cox trees (Plot CE190) on rootstocks from the East Malling breeding programme planted in spring 2004. (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).

Rootstock	Cumulative yield 2004-10 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >65 mm	
AR801-11	24.2	8.8	2.87
AR680-2	30.1	14.2	3.06
M9	37.2	15.4	3.30
SED (28df)	5.47	3.51	0.288
LSD (P=0.05)	11.20	7.19	0.590
Rootstock effect	*	ns	ns

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Table 3. Growth and cropping in 2011 of Queen Cox trees (Plot CE190) on rootstocks from the East Malling breeding programme planted in spring 2004. (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).

Rootstock	**Girth 2011 (cm / tree)**	**Tree Volume 2011 (m^3)**	**Yield 2011 (kg/tree)**	**Yield Class 1 >65 mm 2011 (kg / tree)**	**Suckers 2011 (No. / tree)**
AR801-11	12.4	5.5	7.3	1.0	2.6
AR680-2	14.1	8.0	12.0	4.0	3.0
M9	13.9	6.8	5.7	1.8	2.0
SED (29 df)	0.86	1.20	2.92	0.93	0.66
LSD (P=0.05)	1.75	2.45	5.97	1.90	1.35
Rootstock effect	ns	ns	*	*	ns

Table 4. Cumulative yield and yield efficiency of Queen Cox trees (Plot CE190) on rootstocks from the East Malling breeding programme planted in spring 2004. (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).

Rootstock	**Cumulative yield 2004-11 (kg / tree)**		**Yield efficiency (kg / cm^2)**
	Total	**Class 1 >65 mm**	
AR801-11	32.3	9.5	2.70
AR680-2	38.5	17.7	2.57
M9	43.0	17.2	2.75
SED (27df)	6.08	4.00	0.244
LSD (P=0.05)	12.47	8.21	0.500
Rootstock effect	ns	ns	ns

Performance of Queen Cox on new East Malling rootstock selections

Under conventional management

Selections AR 486-1, AR 295-6 and 120-242 (Plot EE195)

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 four and five 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 was anticipated that as the trees got older any potential differences between the budded and grafted trees would diminish and it would be appropriate to use all eight replicate trees in the statistical analysis.

In 2010 there were no significant differences in tree volume, yield or Class 1 yield for either AR 486-1, AR 295-6 or AR 120-242 compared to M9. However AR 120-242 has

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significantly larger girth, cumulative Class 1 yield and yield efficiency compared to M9, along with a lower number of suckers per tree.

In 2011 there were no significant differences in tree volume of yield, however there were differences in cumulative yield and yield efficiency, but no improvements on M9.

Table 5. Growth and cropping in 2010 of Queen Cox trees (EE195) on rootstocks from the East Malling breeding program planted in spring 2003. 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).

Rootstock	Girth 2010 (cm / tree)	Tree Volume 2010 (m^3)	Yield 2010 (kg/tree)	Yield Class 1 >65 mm 2010 (kg / tree)	Suckers 2010 (No. / tree)
M9	13.1	8.2	9.8	3.1	2.3
AR 486-1	11.9	7.4	11.8	3.2	1.0
AR 295-6	11.8	8.1	12.2	1.9	0.3
AR 120-242	15.1	9.2	8.8	1.4	0.0
SED (9 df)	0.67	0.67	3.29	1.13	0.72
LSD (P=0.05)	1.53	1.51	7.44	2.55	1.62
Rootstock effect	**	n.s.	n.s.	n.s.	*

Table 6. Cumulative yield and yield efficiency of Queen Cox trees (Plot EE195) on rootstocks from the East Malling breeding program planted in spring 2003. 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).

Rootstock	Cumulative yield 2004-10 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >65 mm	
M9	57.1	18.3	5.08
AR 486-1	42.0	13.6	4.20
AR 295-6	54.3	20.9	5.43
AR 120-242	58.6	24.8	3.49
SED (9 df)	7.46	2.43	0.630
LSD (P=0.05)	16.88	5.50	1.426
Rootstock effect	n.s.	**	*

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Table 7. Growth and cropping in 2011 of Queen Cox trees (EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. Data presented for blocks 1-8 (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).

Rootstock	Girth 2011 (cm / tree)	Tree Volume 2011 (m^3)	Grubbing Weight (kg)	Yield 2011 (kg/tree)	Yield Class 1 >65 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
M9	13.4	6.2	3.8	12.9	3.6	2.1
AR 486-1	11.8	5.0	2.4	7.9	2.3	2.3
AR 295-6	12.7	6.1	3.5	9.6	4.5	0.1
AR 120-242	15.2	5.4	3.8	9.3	4.6	0.0
SED (20 df)	0.69	0.98	0.51	2.33	1.52	0.64
LSD (P=0.05)	1.44	2.04	1.05	4.87	3.18	1.34
Rootstock effect	***	ns	*	ns	ns	**

Table 8. Cumulative yield and yield efficiency of Queen Cox trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. Data presented for blocks 1-8 (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).

Rootstock	Cumulative yield 2004-11 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >65 mm	
M9	69.5	25.3	4.86
AR 486-1	47.2	15.7	4.32
AR 295-6	65.5	26.6	5.12
AR 120-242	68.8	30.3	3.82
SED (9 df)	6.28	3.53	0.424
LSD (P=0.05)	13.11	7.37	0.884
Rootstock effect	**	**	*

Performance of Queen Cox on new East Malling rootstock selections

Under organic management

Selections AR 486-1, AR 295-6 and 120-242 (Plot GE182)

There were only sufficient grafted 2-year-old trees of AR 295-6 to complete four of the eight blocks. The remaining blocks were completed using budded 1-year-old trees. In order to compare all rootstocks the analysis of the growth data was necessarily restricted to the four complete blocks of grafted trees. It was anticipated that as the trees get older any potential differences between the budded and grafted trees will diminish and is now appropriate to

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use all eight 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.

As noted in previous reports for TF 172 there was a major impact of the production system on tree performance in 2010. Average tree volume and trunk girth were reduced by 15 and 18% respectively through the adoption of organic management. More importantly the yield of trees under organic management was reduced by 41% of that achieved under conventional management.

There were no significant differences between M9 and the three selections in the 2010 or 2010 cumulative data for any of the measured parameters. In 2011 there were no differences in yields, cumulative yields or yield efficiency between M9 and the three selections evaluated.

Table 9. Growth in 2010 of Queen Cox trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003 and managed under organic conditions. 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).

Rootstock	Girth 2010 (cm / tree)	Tree Volume 2010 (m^3)	Yield 2010 (kg/tree)	Yield Class 1 >65 mm 2010 (kg / tree)	Suckers 2010 (No. / tree)
M9	10.8	8.0	7.3	2.7	0.0
AR 486-1	10.1	6.1	7.7	1.9	1.0
AR 295-6	9.9	5.8	5.0	1.7	0.0
AR 120-242	12.0	8.0	5.3	0.8	0.0
SED (8 df)	0.91	1.54	1.80	0.87	-
LSD (P=0.05)	2.09	3.56	4.14	2.00	-
Rootstock effect	ns	ns	ns	ns	-

(- insufficient data to allow statistical analysis)

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

Rootstock	Cumulative yield 2004-10 (kg / tree)		Yield efficiency
	Total	Class 1 >65 mm	(kg / cm^2)
M9	14.1	3.8	1.55
AR 486-1	14.2	3.6	1.74
AR 295-6	10.7	2.8	1.36
AR 120-242	16.8	4.0	1.51
SED (8 df)	3.10	1.20	0.347
LSD (P=0.05)	7.16	2.77	0.800
Rootstock effect	ns	ns	ns

Table 11. Growth in 2011 of Queen Cox trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003 and managed under organic conditions. Data presented for all blocks. (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).

Rootstock	Girth 2011 (cm)	Tree Volume 2011 (m^3)	Grubbing Weight (kg)	Yield 2011 (kg/tree)	Yield Class 1 >65 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
M9	11.9	6.2	3.5	2.8	0.6	0.0
AR 486-1	11.6	4.5	2.7	1.7	0.9	0.3
AR 295-6	11.2	4.1	2.3	2.6	1.1	0.0
AR 120-242	13.6	6.1	3.5	3.4	1.3	0.0
SED (19 df)	0.75	0.74	0.43	1.53	0.67	-
LSD (P=0.05)	1.58	1.55	0.90	3.21	1.40	-
Rootstock effect	*	*	*	ns	ns	-

(- insufficient data to allow statistical analysis)

Table 12. Cumulative yield and yield efficiency of Queen Cox trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003. Data presented for all blocks. (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).

Rootstock	Cumulative yield 2004-11 (kg / tree)		Yield efficiency
	Total	Class 1 >65 mm	(kg / cm^2)
M9	18.5	4.3	1.70
AR 486-1	15.3	4.8	1.42
AR 295-6	14.7	3.3	1.46
AR 120-242	20.2	5.8	1.40
SED (19 df)	2.89	1.27	0.281
LSD (P=0.05)	6.04	2.65	0.588
Rootstock effect	ns	ns	ns

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

Under conventional management

Selections AR 628-1, AR 69-7, AR 360-19 and AR 801-11 (Plot EE195)

The design of the trial on plot EE195 was complicated by having insufficient numbers of grafted trees available of AR 360-19 and AR 801-11 to complete eight blocks as planned. There were sufficient two year grafted trees for five blocks of these rootstocks and eight blocks of AR 628-2, AR 69-7 and M27 controls. Additional trees of one year budded material were used to complete the blocks.

It was expected that the new rootstock selections would confer tree sizes in the M27-M9 range, with the exception of AR 801-11 which should have a vigour status closer to M26. It was anticipated that as the trees got older any potential differences due to tree age at planting would diminish.

In 2010, as in previous years, AR 360-19 and AR 69-7 showed no significant differences to M27. In 2010 AR 628-2 had a significantly smaller tree volume and girth than M27 without significantly reducing total yield, >80 mm yield and yield efficiency. Cumulative yield, total yield and >80 mm yield were however significantly less. AR 801-11 is statistically more vigorous than M27 and has had greater cumulative total and >80 mm yields than M27.

In 2011 when the plot was grubbed AR 628-2 was significantly lighter than M27 and AR 801-11 was heavier, however yield efficiencies were not significantly different.

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Table 13. Growth and cropping in 2010 of Bramley's Seedling trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Girth 2010 (cm / tree)	Tree Volume 2010 (m^3)	Yield 2010 (kg/tree)	Yield Class 1 >80 mm 2010 (kg / tree)	Suckers 2010 (No. / tree)
M27	11.9	4.2	4.9	3.0	1.4
AR 360-19	11.2	4.0	7.0	4.8	2.0
AR 69-7	11.8	3.1	5.6	1.4	0.0
AR 628-2	8.2	0.9	4.1	0.8	0.8
AR 801-11	18.2	11.7	5.8	5.2	0.4
SED (15 df)	0.96	1.01	3.26	1.86	0.68
LSD (P=0.05)	2.04	2.15	6.95	3.97	1.46
Rootstock effect	***	***	n.s.	n.s.	n.s.

Table 14. Cumulative yield and yield efficiency of Bramley's Seedling trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Cumulative yield 2004-10 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >80 mm	
M27	26.1	15.1	2.68
AR 360-19	25.2	13.6	2.85
AR 69-7	19.9	8.1	1.96
AR 628-2	12.6	1.1	2.25
AR 801-11	49.3	27.8	2.21
SED (12 df)	6.06	3.76	0.434
LSD (P=0.05)	13.20	8.20	0.946
Rootstock effect	***	***	n.s.

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Table 15. Growth and cropping in 2011 of Bramley's Seedling trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Girth 2011 (cm / tree)	Tree Volume 2011 (m^3)	Grubbing Weight (kg)	Yield 2011 (kg/tree)	Yield Class 1 >80 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
M27	12.7	4.2	2.6	5.7	2.3	1.6
AR 360-19	11.7	3.9	2.2	5.1	0.7	1.8
AR 69-7	12.2	2.8	2.4	3.9	0.5	0.0
AR 628-2	8.2	1.1	0.8	0.9	0.3	0.3
AR 801-11	19.2	9.8	7.4	22.5	6.5	0.8
SED (15 df)	0.94	0.75	0.68	3.87	1.19	0.56
LSD (P=0.05)	2.01	1.60	1.45	8.25	2.54	1.19
Rootstock effect	***	***	***	***	***	*

Table 16. Cumulative yield and yield efficiency of Bramley's Seedling trees (Plot EE195) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Cumulative yield 2004-11 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >80 mm	
M27	31.7	17.3	2.44
AR 360-19	30.3	14.3	2.80
AR 69-7	26.1	8.5	2.09
AR 628-2	13.4	0.8	2.21
AR 801-11	71.8	34.4	2.39
SED (12 df)	9.01	4.62	0.464
LSD (P=0.05)	19.64	10.06	1.011
Rootstock effect	***	***	ns

Under organic management

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

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.

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In 2010 AR 69-7 had a statistically greater girth and tree volume than M27 but showed no other statistical differences for any of the other measured parameters. AR 360-19 and AR 628-2 were not statistically different to M27 in 2010 and AR 801-11 had a significantly higher girth, tree volume and cumulative yield than M27.

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 was expected that these rootstocks are likely to provide tree sizes in the M27-M9 range with the exception of AR 801-11, which should have a vigour status closer to M26. It was anticipated that as the trees aged any potential differences due to tree age at planting would diminish.

Table 17. Growth and cropping in 2010 of Bramley's Seedling trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	**Girth 2010 (cm / tree)**	**Tree Volume 2010 (m^3)**	**Yield 2010 (kg/tree)**	**Yield Class 1 >80 mm 2010 (kg / tree)**	**Suckers 2010 (No. / tree)**
M27	9.5	1.8	2.4	#	0.2
AR 360-19	8.6	1.5	4.2	#	0.4
AR 69-7	12.6	6.1	4.0	#	0.0
AR 628-2	7.2	0.4	0.9	#	0.2
AR 801-11	16.7	8.0	6.4	#	0.0
SED (16 df)	1.44	1.48	2.09	#	-
LSD (P=0.05)	3.04	3.15	4.43	#	-
Rootstock effect	***	***	ns	#	-

(- insufficient data to allow statistical analysis)
(# no data available for this parameter)

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Table 18. Cumulative yield and yield efficiency of Bramley's Seedling trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	**Cumulative yield 2004-10 (kg / tree)**		**Yield efficiency**
	Total	**Class 1 >80 mm**	**(kg / cm^2)**
M27	6.3	#	0.96
AR 360-19	6.8	#	1.16
AR 69-7	9.4	#	0.69
AR 628-2	2.7	#	0.66
AR 801-11	12.3	#	0.56
SED (16 df)	2.54	#	0.260
LSD (P=0.05)	5.39	#	0.550
Rootstock effect	*	#	ns

(# no data available for this parameter)

Overall there was a major impact of the production system on tree performance. In 2010 average tree volume and trunk girth were reduced by 26 and 11% respectively through the adoption of organic management. More importantly the yield of trees under organic management was reduced by 35% compared to the average yield achieved under conventional management.

In 2011 at the time of grubbing only AR 801-11 was greater in girth, tree volume and weight than M27. AR 69-7 was greater in girth and weight but not tree volume. The other two selections were not significantly different from M27. Although AR 801-11 had a greater total cumulative yield than M27, yield efficiency was not significantly different.

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Table 19. Growth and cropping in 2011 of Bramley's Seedling trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Girth 2011 (cm)	Tree Volume 2011 (m^3)	Grubbing Weight (kg)	Yield 2011 (kg/tree)	Yield Class 1 >80 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
M27	10.0	2.3	1.8	0.3	0.0	0.0
AR 360-19	9.2	1.7	1.4	1.0	0.0	0.4
AR 69-7	13.6	5.2	3.6	2.3	0.5	0.0
AR 628-2	7.3	0.4	0.8	0.7	0.0	0.4
AR 801-11	17.5	6.7	5.8	2.4	0.1	0.0
SED (16 df)	1.54	1.40	0.80	1.64	0.15	-
LSD (P=0.05)	3.26	2.98	1.69	3.49	0.32	-
Rootstock effect	***	**	***	ns	*	-

(- insufficient data to allow statistical analysis)

Table 20. Cumulative yield and yield efficiency of Bramley's Seedling trees (Plot GE182) on rootstocks from the East Malling breeding programme planted in spring 2003. 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).

Rootstock	Cumulative yield 2004-11 (kg / tree)		Yield efficiency (kg / cm^2)
	Total	Class 1 >80 mm	
M27	6.7	0.5	0.96
AR 360-19	7.8	0.5	1.12
AR 69-7	11.7	2.6	0.76
AR 628-2	3.4	0.0	0.83
AR 801-11	14.7	1.5	0.62
SED (16 df)	3.22	0.92	0.248
LSD (P=0.05)	6.83	1.96	0.526
Rootstock effect	*	*	ns

Performance of Braeburn on new East Malling rootstock selections

Under conventional management

Selections AR852-3, AR839-9, B24, R104 and R59 (Plot EE207)

Due to uneven block size it was not possible to run the conventional Genstat ANOVA, instead a Genstat Regression analysis was used with an unbalanced design. This method

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of analysis meant that the tconventional results table showing SEDs and LSDs was not possible as these values were calculated separately for each rootstock/factor combination. Shoot length and number was statistically lower for R59 than M26 (semi-dwarfing) whereas none of the other selections were significantly different and, although growth was reduced in R59 compared to M26, total yield was increased. Vigour of the other selections, in terms of shoot length and shoot number, was similar to M9 (dwarfing), and greater than M27 (very dwarfing) for AR852-3, B24 and R104. Total yields were not significantly different or were lower than for M9 and M27.

Table 21. Growth and cropping in 2011 of Braeburn trees (Plot EE207) on rootstocks from the East Malling breeding programme planted in spring 2010. Rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability). Due to uneven block size it was not possible to run traditional Genstat ANOVA, instead

Rootstock	Girth 2011 (cm / tree)	Total Shoot Length 2011 (dm)	Total Shoot Number 2011	Yield 2011 (kg/tree)	Yield Class 1 >65 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
AR852-3	5.4	41.8	18.0	0.54	0.26	0.0
AR839-9	4.3	34.0	15.4	0.11	0.07	0.0
B24	4.2	45.0	19.4	0.15	0.06	0.1
R104	5.5	53.2	22.5	0.29	0.14	0.0
R59	4.3	25.0	12.1	0.61	0.27	0.0
M26	5.8	47.5	20.9	0.17	0.11	0.0
M9	5.2	31.4	15.4	0.44	0.19	0.6
M27	4.0	19.1	9.7	0.42	0.05	0.3
Rootstock effect	***	**	**	***	n.s.	n.s.

Performance of Gala on new East Malling rootstock selections

Under conventional management

Selections AR852-3, AR839-9, B24, R104 and R59 (Plot EE207)

Due to uneven block size it was not possible to run conventional Genstat ANOVA, instead a Genstat Regression analysis was used with an unbalanced design. This method of analysis meant that the conventional results table showing SEDs and LSDs was not possible as these values were calculated separately for each rootstock/factor combination.

With Royal Gala as the scion variety vigour in terms of shoot length and shoot number was again less for R59 than M26 but the vigour of AR852-3 was also less than that of M26. The vigour of R59 was also less than M9 and similar to that of M27. B24 and R104 fall in the

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vigour range M9 – M27. Yields were greater for R59 than M26 or M9 but not statistically different from that of M27.

Table 22. Growth and cropping in 2011 of Royal Gala trees (Plot EE207) on rootstocks from the East Malling breeding programme planted in spring 2010. Rootstock effect was either non-significant (n.s.) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability).

Rootstock	**Girth 2011 (cm / tree)**	**Total Shoot Length 2011 (dm)**	**Total Shoot Number 2011**	**Yield 2011 (kg/tree)**	**Yield Class 1 >65 mm 2011 (kg / tree)**	**Suckers 2011 (No. / tree)**
AR852-3	5.2	36.2	13.2	0.42	0.21	0.1
AR839-9	5.1	42.9	15.2	0.01	0.00	0.7
B24	5.8	60.6	24.4	0.06	0.03	0.3
R104	5.8	44.0	20.2	0.08	0.02	0.1
R59	4.7	27.9	12.5	0.52	0.32	0.7
M26	6.3	53.6	24.1	0.06	0.07	0.6
M9	5.8	42.8	18.9	0.19	0.10	0.1
M27	4.3	20.0	11.6	0.29	0.10	0.5
Rootstock effect	***	***	***	**	*	n.s.

Performance of Red Falstaff on new East Malling rootstock selections

Under conventional management

Selections AR835-11, AR809-3, AR10-3-9 and R80 (Plot VF224)

Girth of AR809-3 was less than that of M116 or MM106 but there were no significant differences in terms of total shoot length and number or yield.

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Table 23. Growth and cropping in 2011 of Red Falstaff trees (Plot VF224) on rootstocks from the East Malling breeding programme planted in spring 2010. (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).

Rootstock	Girth 2011 (cm / tree)	Total Shoot Length 2011 (dm)	Total Shoot Number 2011	Yield 2011 (kg/tree)	Yield Class 1 >65 mm 2011 (kg / tree)	Suckers 2011 (No. / tree)
AR10-3-9	4.5	10.9	8.1	0.39	0.03	0.0
AR809-3	3.8	3.6	3.3	0.28	0.00	0.0
AR835-11	4.3	7.8	5.9	0.33	0.04	0.0
R80	4.7	10.1	7.3	0.76	0.13	0.0
M116	4.8	7.6	6.1	0.44	0.06	0.0
MM106	4.7	10.0	6.6	0.49	0.03	0.0
SED (35 df)	0.30	2.40	1.50	0.18	0.04	-
LSD (P=0.05)	0.61	4.88	3.05	0.37	0.08	-
Rootstock effect	*	n.s.	n.s.	n.s.	n.s.	-

(- insufficient data to allow statistical analysis)

Performance of Comice and Conference on Quince (EMC and C132) and Pyrus (BP30) rootstocks

The trees on plot PR184 were budded at a height of 10 and 25 cm. Previous work (see final report for APRC on SP123) had shown that increasing the height of budding on Comice reduced the vigour of trees on EMC rootstock.

In 2010 cumulative Yield of Class I fruit was significantly greater on C132 than on EMC or BP30. However yield efficiency was not statistically different for the three rootstocks.

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Table 24. Cropping in 2010 of Comice and Conference trees on Quince (EMC and C132) and *Pyrus* (BP30) rootstocks planted spring 1999 (Plot PR184). (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).

Cultivar	Rootstock	Graft height (cm)	Total yield (kg / tree)		Yield Class 1 >65 mm (kg / tree)	
			2010	Cumulative	2010	Cumulative
Comice	EMC	10	4.9	85.7	3.9	64.6
	EMC	25	4.4	91.3	3.5	66.4
	BP30	10	4.2	69.1	3.2	49.5
	BP30	25	5.0	77.9	3.9	61.0
	C132	10	3.4	94.7	2.9	80.6
	C132	25	5.7	93.9	4.8	79.6
Conference	EMC	10	3.5	61.2	0.2	5.7
	EMC	25	3.9	65.9	0.4	5.0
	BP30	10	4.8	54.0	1.7	9.2
	BP30	25	7.8	65.2	0.9	7.4
	C132	10	4.5	66.9	1.0	11.0
	C132	25	4.3	69.1	0.4	13.4
Overall effect	EMC		4.2	76.0	2.0	35.4
	BP30		5.5	66.5	2.4	31.8
	C132		4.5	81.1	2.3	46.1
SED(91 df)			1.03	4.09	0.81	2.88
LSD (P=0.05)			2.04	8.12	1.60	5.73
Rootstock effect			n.s.	**	n.s.	***

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Table 25. Growth in 2010 of Comice and Conference trees on Quince (EMC and C132) and *Pyrus* (BP30) rootstocks planted spring 1999 (Plot PR184). (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).

Variety	Rootstock	Graft Height (cm)	Girth 2010 (cm / tree)	Tree Volume 2010 (m^3)	Grubbing Weight 2010 (kg)	Yield efficiency (kg / cm^2)
Comice	EMC	10	26.2	6.9	9.6	1.56
	EMC	25	23.9	5.5	8.8	2.03
	BP30	10	22.6	4.0	6.6	1.75
	BP30	25	24.0	4.2	7.6	1.73
	C132	10	29.3	6.9	11.6	1.44
	C132	25	25.5	5.9	9.5	1.83
Conference	EMC	10	18.9	4.4	5.8	2.16
	EMC	25	17.6	4.1	5.1	2.69
	BP30	10	16.8	3.3	4.1	2.33
	BP30	25	19.8	3.3	5.1	2.07
	C132	10	21.9	5.7	7.6	1.75
	C132	25	18.4	4.5	5.8	2.55
Overall effect	EMC		21.6	5.2	7.3	2.11
	BP30		20.8	3.7	5.8	1.97
	C132		23.7	5.8	8.6	1.89
SED (91 df)			0.62	0.36	0.40	0.094
LSD (P=0.05)			1.23	0.71	0.80	0.186
Rootstock effect			***	***	***	n.s.

The on-farm trial was planted during the winter of 2009-2010 and fruit has yet to be produced, however it is now believed that the C132 material used in the trial is not true to type.

International plum rootstock trial

The trial was brought to a premature end after the 2008 growing season. The grower hosting the trial required the land for other purposes and the trees were duly grubbed in the winter of 2008/9.

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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 2010. In 2010 yield, yield efficiency and tree volume were significantly greater for LC52 than VSL2. LC52 produced significantly fewer suckers than VSL2. In 2011 girth, tree volume, grubbing weight, total yield, total cumulative yield and yield efficiency were all greater for LC52 than for VSL2.

Table 26. The effect of rootstock on the growth and cropping of 'Summersun' cherry trees in 2010. Trees planted on plot MP177 at EMR on 18 April 2002. (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).

Rootstock	**2010 data**					**Cumulative data (2003-2010)**	
	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)**
LC52	39.8	32.8	15.0	7.5	0.3	81.0	0.69
VSL2	34.0	26.2	8.9	7.4	1.7	50.6	0.58
SED (17 df)	1.55	3.56	2.33	0.43	0.45	5.73	0.026
LSD (P=0.05)	3.27	7.51	4.92	0.91	0.94	12.09	0.055
Effect of Rootstock	**	ns	*	ns	**	***	***

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Table 27. The effect of rootstock on the growth and cropping of 'Summersun' cherry trees in 2011. Trees planted on plot MP177 at EMR on 18 April 2002. (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).

Rootstock	2011 data						Cumulative data (2003-2011)	
	Girth (cm)	**Tree Volume (m^3)**	**Grubbing Weight (kg)**	**Total Yield (kg)**	**Mean Fruit Weight (g)**	**Suckers (No./tree)**	**Total Yield (kg/tree)**	**Yield efficiency (kg/cm^2)**
LC52	41.1	25.7	35.8	11.7	9.1	1.3	92.7	0.69
VSL2	34.8	18.0	20.1	5.7	8.9	2.8	56.3	0.59
SED (17 df)	1.67	2.72	3.90	2.29	0.27	0.75	7.23	0.029
LSD (P=0.05)	3.53	5.74	8.23	4.84	0.58	1.58	15.26	0.061
Effect of Rootstock	**	*	***	*	ns	*	***	**

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

Although yield was significantly greater for Gisela 5 in 2010, differences between Gisela 3 and Gisela 5 rootstocks were not significant in 2011.

Table 28. The effect of Gisela rootstocks on the growth and cropping of 'Penny' cherry trees in 2010. Trees planted on plot MP186 at EMR in March 2006. (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).

Rootstock	2010 Data					Cumulative Data (2007-2010)	
	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	20.4	19.9	7.5	11.7	0	11.6	0.41
Gisela 5	22.4	22.5	11.6	11.1	0	16.9	0.48
SED (7 df)	0.89	2.32	0.79	0.28	-	1.80	0.040
LSD (P=0.05)	2.10	5.49	1.87	0.66	-	4.99	0.112
Effect of Rootstock	ns	ns	**	ns	-	*	ns

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Table 29. The effect of Gisela rootstocks on the growth and cropping of 'Penny' cherry trees in 2011. Trees planted on plot MP186 at EMR in March 2006. (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).

Rootstock	**2011 Data**					**Cumulative Data (2007-2011)**	
	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	22.2	19.6	7.1	8.5	0.1	18.6	0.47
Gisela 5	24.1	20.3	6.5	8.7	0.0	23.4	0.48
SED (7 df)	1.00	1.65	0.80	0.12	0.13	2.60	0.046
LSD (P=0.05)	2.36	3.89	1.90	0.28	0.30	7.22	0.128
Effect of Rootstock	ns	ns	ns	ns	ns	ns	ns

EMR rootstock selections tested on 'Sunburst' (plot MP 182)

There were no significant differences in yield between the assessed rootstocks in 2010 and, although there were differences in the 2011 yields, there were no statistical differences in cumulative yield in 2011. However yield efficiency was shown to be greatest for Gisela 5 in both 2010 and 2011. C376-1 had the greatest tree volume, greater than Gisela 5 and C113-3 had the smallest tree volume, smaller than Tabel Edabriz.

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Table 30. The effect of EMR rootstock selections on the growth and cropping of 'Sunburst' cherry trees in 2010. Trees planted on plot MP182 at EMR in April 2005. (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).

Rootstock	2010 data					Cumulative data (2008-2010)	
	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)**
C113-3	16.7	11.7	0.9	8.3	0.0	2.3	0.10
C376-1	25.6	27.7	5.9	12.9	0.2	10.6	0.18
C376-4	24.0	28.2	5.5	11.0	0.5	9.2	0.21
C376-5	21.9	21.4	5.9	8.9	1.0	9.7	0.25
Tabel Edabriz	20.7	17.5	3.5	10.3	0.0	7.5	0.21
Gisela 5	20.1	23.2	6.6	9.9	0.5	11.6	0.37
SED (16 d.f)	2.39	6.48	3.15	1.51	1.03	4.08	0.079
LSD (P=0.05)	5.07	13.74	6.68	3.22	2.19	8.64	0.167
Effect of Rootstock	**	*	ns	*	ns	ns	*

Table 31. The effect of EMR rootstock selections on the growth and cropping of 'Sunburst' cherry trees in 2011. Trees planted on plot MP182 at EMR in April 2005. (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).

Rootstock	2011 data					Cumulative data (2008-2011)	
	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)**
C113-3	16.9	9.7	0.3	7.7	1.3	3.0	0.12
C376-1	27.6	19.1	3.1	11.4	0.4	13.7	0.19
C376-4	26.2	17.0	1.9	11.3	1.0	11.1	0.21
C376-5	24.5	18.6	2.4	12.0	0.5	13.1	0.28
Tabel Edabriz	22.3	14.0	2.2	11.8	0.0	9.6	0.24
Gisela 5	21.1	16.6	4.4	10.9	0.5	16.0	0.46
SED (14 d.f)	2.87	3.20	1.18	1.63	0.98	5.21	0.082
LSD (P=0.05)	6.16	6.87	2.54	3.49	2.11	11.18	0.183
Effect of Rootstock	**	*	*	*	ns	ns	*

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Discussion

The overall aim of the project was to acquire, evaluate and develop in UK growing conditions new apple, pear, cherry and plum rootstocks produced by breeding programmes both at EMR and abroad. This has been achieved through a rolling programme of new plantings and grubbing over the course of this project. Data have been evaluated on the basis of individual years and as cumulative data. The production and selection of tree fruit rootstocks is a process that requires a considerable time, evaluating the trees over several seasons. Evaluation of some of the more promising selections in recent plantings and some new plantings will continue in another HDC funded project.

Apple:

Plantings comparing new selections of rootstocks with combinations of the standards M9, M26, M27, M116 and MM106 have been evaluated over the course of the project in conventional and organic growing systems. These plantings have started with Cox and Bramley as scion varieties, but more recent plantings have Braeburn, Royal Gala and Red Falstaff as these are varieties that are now commonly planted.

Many of the selections evaluated show characteristics not significantly different to the M and MM series standards used as comparisons in the individual plots, or show some characteristics as more desirable than those of the standards and some as less desirable. For instance there were no significant differences in cumulative yield, total and Class I, and yield efficiency between any of the rootstocks evaluated in plot GE182.

However, there has been one promising selection, AR295-6, slightly less vigorous than M9 but with better yield efficiency and anchorage. This is now being propagated by European nurserymen where high health status mother trees will be planted in spring 2013. A US patent will be applied for in 2013 and EU Plant Breeders Rights in 2013/2014.

Pear:

One of the main objectives was to develop a quince rootstock more dwarfing than Quince C and with improved precocity of cropping. The quince rootstock C132 was a potential candidate which at first looked promising but has given contradictory results in two plots planted at EMR. In the last plot to be grubbed C132 showed greater or equal vigour to Quince C for Conference (variability depending on graft height) but no significant differences in yield efficiency. BP30 was a Swedish *Pyrus* selection that initially appeared slightly more vigorous than Quince C but with similar cumulative yield. Results at the end of

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the trial showed BP30 to be less vigorous than Quince C but with similar cumulative yield and greater yield of Class I fruit.

Cherry:

The main objective here was to select fully dwarfing rootstocks that are easy to propagate and that induce good yield precocity, fruit size and sustained productivity. Gisela 5 is now the most commonly planted cherry rootstock in the UK and two of the trial plots contained this rootstock. It is difficult to assess the relative worth of LC52 and VSL2 as they were planted three and four years prior to the other cherry plots and did not contain Gisela 5. Comparing data from the orchards when at the same age, tree volume for VSL2 is likely to be similar to Gisela 5, as is yield efficiency. Of the more recent plantings, tree volume is not significantly different between Gisela 3 and 5 but total yield is greater for Gisela 5 and for the most recent planting Gisela 5 has the greatest total yield and yield efficiency of the rootstocks assessed.

Plum:

The trial was brought to a premature end after the 2008 growing season. The grower hosting the trial required the land for other purposes and the trees were duly grubbed in the winter of 2008/9. The trial had been disappointing with respect to the level of cropping achieved. The first significant crop was produced in 2006 but in 2007 the trial was ravaged by several severe hail storms and consequently no fruit records were taken. In 2008 there were severe frosts and only the Opal trees retained sufficient fruit to justify yield records being taken. Conclusions on the effects of rootstocks on yield, yield efficiency and fruit size were limited by the lack of data available. Subsequent to the end of the plum rootstock part of this project, the HDC commissioned project TF 157 which evaluated a range of plum rootstocks.

Conclusions

Apple:

- A successful selection from the programme has been made: AR295-6, (slightly less vigorous than M9 but with better yield efficiency and anchorage), which is now being propagated by European nurserymen. High health status mother trees will be planted spring 2013, a US patent will be applied for in 2013 and Plant Breeders Rights in 2013/2014

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Pear:

- C132 is not a suitable replacement for Quince C
- BP30 is a potential rootstock where *Pyrus* rootstocks are preferred to quince

Cherry:

- Gisela 5 is the most suitable rootstock for UK cherry production, being reasonably dwarfing and with a high yield efficiency
- VSL2 may have some merit

Plum:

- No definite conclusions could be drawn from the project

Knowledge and Technology Transfer

HDC News June 2008. Rootstocks: the next generation

HDC News September 2010. New Era for rootstocks

References

Johnson D., Evans K., Spencer J., Webster, T. and Adam, S. (2005). Orchard Comparisons of New Quince and Pyrus Rootstock clones. *Acta Horticulturae* (ISHS) 671: 201-207