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 EM Trust for Horticultural Research, with additional funding from the Apple and Pear Research Council (APRC) in 2000-01. A report on the work carried out during that six-year period was prepared by Dr Tony Webster and colleagues and submitted to APRC (SP123) and the EM Trust in 2001. In 2001-02, the evaluation and development of new rootstocks for apples and pears was continued in a one-year APRC project (SP134) and a report on the work carried out from April 2001 until March 2002 was submitted to APRC in April 2002. Subsequently, the APRC Council agreed to continue project SP134 for a further three years (March 2005), and they also decided to fund additional work (SP141) to evaluate and develop in organic growing conditions new apple rootstocks produced by the breeding programme at EMR. Since April 2003, these projects have been funded by the HDC (TF 134 and TF 141). This is a report on the work carried out from April 2004 until March 2005. 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 (M.116).

Apple rootstock trials planted at East Malling

Currently, two trials of apple rootstocks raised by breeders based outside of the UK are planted.

In the older (Queen Cox) trial planted in spring 1995 (Plot DM167), new rootstocks from the Geneva New York breeding programme are being compared with M.9 and MM.106. These rootstocks, some of which are now becoming available commercially in Europe, were bred to provide improved resistances to winter cold injury, fireblight, woolly apple aphid, crown rot and tomato ringspot virus. Several rootstocks from this programme are showing initial promise in trials conducted in New Zealand and the USA. With vigour closer to M.26 than to M.9, one or more of these rootstocks may

have potential on sites where there is significant weed/grass competition for water and nutrients.

The younger (Mondial Gala) trial planted in spring 2000 (Plot DM172) compares three of the rootstocks raised at the Vineland Research Station in Canada with the French Pajam 2 rootstock. These rootstocks are M.9-M.26 in vigour, but possibly have better cold and drought resistance than M.9. The Vineland series of rootstocks were bred to provide improved cold tolerance, but have also performed well in less severe conditions on some USA sites.

Currently, three trials of apple rootstocks raised by breeders at EMR are planted.

A trial was planted on 8 May 2003 (Plot EE 195) to evaluate new rootstocks from the breeding program at East Malling. 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 GE182) at East Malling. Although the performance of rootstocks under organic management is being assessed in a separate project (TF 141), it is appropriate to combine the reporting of rootstock trials under conventional and organic management.

A new trial was planted on 18 May 2004 (Plot CE 190) to evaluate new rootstocks from the breeding program at East Malling. Using Queen Cox, two new rootstock selections (AR 801-11 and AR 680-2) are being compared with M.9, M.26 and MM.106.

Pear rootstock trials planted at East Malling

Three trials of quince and *Pyrus* rootstocks planted at East Malling continue to be evaluated. Two of these trials include C.132, a quince rootstock from the HRI breeding programme, which is slightly more dwarfing than Quince C and possibly more winter hardy. In one of these trials (Plot PR 184), C.132 is compared with Quince C (EMC) and a promising Swedish *Pyrus* selection (BP30) and, in the other (Plot PR173), it is compared with EMC and a dwarfing *Pyrus* selection from the HRI programme, QR

708/2. In the third trial (Plot PR187), a new dwarfing *Pyrus* selected at Geisenheim, in Germany, named 'Pyrodwarf' is being evaluated along with the quince rootstock 'Sobu', and pear scion varieties as potential rootstocks.

The performance of EMH, EMA and EMC rootstocks on Concorde and Conference has continued at one commercial orchard in East Kent.

Materials and Methods

In all of the East Malling trials, the tree rows were maintained weed free using conventional herbicides (excluding the organic trial on Plot GE182) 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 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 annually of trunk girth 25cm above ground level and of shoot length and the numbers of shoots were counted. Total yields and yields of Class 1 fruit above 65mm diameter were measured and cumulative yields and yield efficiencies were calculated. In 2004, an additional size grade was introduced for Conference pears (55-65mm diameter) since this has more commercial relevance than the >65mm category used for apples and Comice pears. Notes on tree health and graft compatibility were also made.

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Results and Discussion

Performance of Queen Cox on Geneva rootstocks (Tables 1 and 2)

Sufficient data has been gathered since 1995 to make an objective assessment of the performance of Queen Cox on the Cornell-Geneva rootstocks. Vigour of the rootstocks can be assessed by the annual girth measurement and by the estimates of tree volume.

Geneva 11 (G.11) was not significantly less vigorous than M.9 as evidenced by girth measurements and tree volume in 2004. Yields in 2004, accumulated yield (total and % Class 1) and yield efficiency were similar to M.9.

Geneva 30 (G.30) was similar to MM.106 with regard to growth although in 2004 the total yield and yield of Class 1 fruit above 65 mm was lower. Accumulated yield (total and % Class 1) was lower and yield efficiency similar to MM106.

Geneva 902 (G.902) has produced trees less vigorous than M.9, but with similar yields (2004 and accumulated) and similar yield efficiency.

Geneva 730 (G.730) has produced trees less vigorous than M.9. In 2004, the total yield and yield of Class 1 fruit above 65 mm was lower than for M.9, as was accumulated yield. However, yield efficiency was similar to M.9.

Geneva 202 (G.202) was of similar vigour (girth) to M.9. Cumulative yield (% Class 1) tended to be higher than for M.9, but yield efficiency was similar.

Geneva 210 (G.210) produced a similar girth and tree volume to M.9. In 2004 total yields and yields of Class 1 fruit above 65mm were similar to M.9. Cumulative yield and yield efficiency were similar to M.9.

Geneva 179 (G.179) was of similar vigour (girth) to M.9 but produced higher total yields and yields of Class 1 fruit above 65mm in 2004. Accumulated yield of Class 1 fruit above 65mm was higher than for M.9 but yield efficiency was similar.

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G.11, G.179, G. 202 and G. 210 rootstocks have performed well in this trial and similarly to M.9, although G.179 produced more yield in 2004 and had a higher accumulated yield of fruit above 65mm. G.730 and G.902 were less vigorous than M.9. Although G.730 had a lower yield in 2004 and a lower accumulated yield than M.9, it had the highest yield efficiency of any of the rootstocks tested, although not significantly more than M.9 at the 5% level of probability. G.902 achieved a similar yield to M.9, both in 2004 and accumulated, and also tended to have higher yield efficiency.

Five of the Geneva rootstocks have been released for commercial propagation and these include three of those in trial at East Malling (G.11, G.30 and G.202). Information on the performance of Cornell-Geneva apple rootstocks in New York on-farm trials has recently been published (Robinson *et al*., 2003). In the USA, G.11 is considered a good replacement for M.26 and has fireblight tolerance similar to M.7, and good resistance to crown rot. G.202 is slightly more vigorous than M.26 and is immune to fireblight and has good resistance to *Phytophthora*, apple replant disease and woolly apple aphid. New Zealand results also confirm the potential of G.202 as a highly productive semi-dwarfing rootstock well adapted for use on replant soils (Tustin *et al.*, 2003). It appears that under climatic conditions that are more conducive to tree growth some of the rootstocks selections that we considered fully dwarfing may perform as semi-dwarfing trees. In trials using McIntosh currently being carried out at the University of Massachusetts, G.179 and G.202 were more vigorous then M.9, whereas vigour was similar to M.9 in trials at EMR (Autio *et al*., 2005).

Table 1. Size and yields (2004 crop) of Queen Cox trees planted on Cornell-Geneva (USA) rootstocks in 1995. (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	Trunk girth 2004 (cm / tree)	Tree volume 2004 (m^3)	Yield 2004 (kg / tree)	
			Total	Class 1 >65 mm
G.730	19.97	14.72	9.82	6.18
G.902	22.89	20.32	19.05	11.53
G.11	25.68	22.70	21.92	12.62
G.179	25.73	30.13	31.64	24.25
G.202	26.87	24.12	19.20	13.92
M.9	27.03	26.18	20.85	14.08
G.210	28.31	27.33	25.47	10.77
G.30	32.98	43.41	24.86	10.65
MM.106	33.92	47.35	44.07	27.42
SED (32 df)	1.063	3.022	3.539	3.433
LSD (P=0.05)	2.163	6.148	7.209	6.992
Rootstock effect	***	***	***	***

Table 2. Accumulated yields and yield efficiencies of Queen Cox trees planted on Cornell-Geneva (USA) rootstocks in 1995. (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 (kg / tree) 1996-2004		Yield efficiency (kg / cm^2) 2004
	Total	Class 1 >65 mm	
G.730	71.8	46.4	2.277
G.902	91.1	52.5	2.225
G.11	117.3	68.2	2.244
G.179	115.7	75.6	2.150
G.202	119.4	72.8	2.134
M.9	101.9	60.7	1.781
G.210	109.9	62.1	1.716
G.30	153.9	84.0	1.751
MM.106	193.1	118.7	2.114
SED (33 df)	10.91	6.87	0.2602
LSD (P=0.05)	22.23	14.00	0.5301
Rootstock effect	***	***	n.s.

Performance of Mondial Gala on Vineland rootstocks

As noted previously (see report on SP 134 to 31 March 2002), at the time of planting in March 2000 the tree quality of these bench grafts was very poor in comparison with the controls used on Pajam 2. The growth of the Vineland rootstocks was poor in the first year but total shoot growth exceeded that of Pajam 2 in 2002 (see report to March 2003). The number of dead or diseased trees for rootstocks V.1, V.3, V.4 and Pajam 2 is currently one, five, three and one out of six respectively. Clearly, it is not possible to assess the performance of trees on V.3 rootstock and results for V.4 are based on only 50% of the trees originally planted. In view of the tree health problem, it is likely that the trial will be terminated in the coming winter.

V.4 was more vigorous than Pajam 2 and tended to be higher yielding in 2004 although yield efficiency was poor (Table 3). V.1 was of similar vigour to Pajam 2 and yield and yield efficiency were similar.

In current trials in Massachusetts, USA, using McIntosh trees on a range of Vineland rootstocks V.4 has proved to the most vigorous, more so than M.26 and comparable to M.7 (Autio and Krupa, 2002). In our trial on Mondial Gala, V.4 was more vigorous than M.9 but had not shown the vigour reported in the US trials. In the latter trials, V.3 was the most dwarfing stock and, along with V.1, has proved to be most yield-efficient. It is unfortunate that health problems have plagued our evaluation of the Vineland stocks, particularly as the results of US trials are favourable, and in the USA further evaluation of V.3 is being suggested (Autio *et al*., 2005).

Table 3. Cropping and trunk girth in 2004 of Mondial Gala trees on Vineland rootstocks planted in spring 2000. (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). †-no data, 5 of 6 trees planted have died

Rootstock	**Total yield (kg / tree)**		**Yield Class 1 >65 mm (kg / tree)**		**Girth (cm / tree)**	**Yield efficiency (kg / cm^2)**
	2004	**Cumulative**	**2004**	**Cumulative**	**2004**	**2004**
Pajam 2	9.4	30.6	5.1	21.3	12.60	2.39
V.1	12.9	26.0	10.2	20.6	13.38	1.65
V.3†						
V.4	16.7	32.1	12.6	19.6	18.15	1.48
SED (5 df)	3.79	9.03	3.24	8.71	1.042	0.464
LSD (P=0.05)	9.74	23.22	8.33	22.40	2.678	1.192
Rootstock effect	n.s.	n.s.	n.s.	n.s.	**	n.s.

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 two-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 one-year-old trees. The analysis of the data for 2004 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.

AR 486-1 appears to be less vigorous than M.9 with a smaller girth, fewer shoots and less shoot growth (Table 4). AR 120-242 continues to have a larger girth than M.9 trees and AR 295-6 again had fewer shoots than M.9. The M.9 trees tended to have a higher number of shoots at the time of planting in 2003. This may reflect the fact that these were produced in the Netherlands, whereas the remaining trees were raised in the UK. It

is too early to comment on fruit production with trees in their second year, although it was interesting to note the high yield associated with AR 486-1 compared with M.9 and other selections.

Table 4. Growth and cropping in 2004 of Queen Cox trees 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 (cm/tree)	Total shoot length (dm/tree)	Total shoot number	Yield (kg/tree)	Yield Class 1 >65 mm (kg/tree)
AR 486-1	6.37	43.0	13.50	2.20	1.75
AR 295-6	6.67	60.8	10.25	0	0
M.9	7.27	73.0	19.50	0.57	0.52
AR 120-242	8.40	75.0	15.00	0.95	0.47
SED (9 df)	0.335	7.81	2.340	0.702	0.410
LSD (P=0.05)	0.758	17.67	5.293	1.588	0.927
Rootstock effect	***	**	*	n.s.	**

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

New selections AR 801-11 and AR 680-2 are being compared with M.9, M.26 and MM106 in a randomised block experiment on plot CE190 at EMR. At planting on 18 May 2004, the new selections had fewer feathers than the named rootstocks and the length of feathers was less on AR 801-11 than on M.9 or M.26. There were no differences in the heights of the trees at planting, but AR 801-11 had a smaller girth than M.9 and M.26 (data not presented). After the first year of growth in the orchard, AR 680-2, AR 801-11 and MM106 had similar girths and less than those of M.9 and M.26 (Table 5). There were fewer shoots and less shoot length on AR 680-2 than on M.9 or M.26. Clearly, it will take a number of growing seasons for the trees to establish and produce fruit.

Table 5. Growth and cropping in 2004 of Queen Cox trees (Plot CE190) on rootstocks from the East Malling breeding program 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	Total feather number at planting	Total feather length (cm) at planting	Girth 2004 (cm/tree)	Total shoot length 2004 (dm/tree)	Total shoot number 2004
AR680-2	1.00	46.1	4.35	7.38	3.82
MM106	2.62	44.4	4.36	9.50	5.00
AR801-11	0.50	17.1	4.43	9.88	4.12
M.26	3.38	75.7	4.83	12.62	6.38
M.9	3.25	75.9	4.93	12.25	6.50
SED (28 df)	0.773	18.06	0.143	1.775	0.918
LSD (P=0.05)	1.584	37.94	0.294	3.641	1.883
Rootstock effect	**	*	***	*	**

Under organic management (Project TF141)

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

There were only sufficient grafted two-year-old trees of AR 295-6 to complete four of the eight blocks respectively. The remaining blocks were completed using budded one-year-old trees. In order to compare all rootstocks, the analysis of the growth data for 2004 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. To compare only AR 486-1, AR 120-242 and M.9 the data can be restricted so that the data for all eight blocks are used.

As in the previous year, AR 486-1 had less shoots than M.9 and tended to make less growth. AR 120-242 had a larger girth than M.9 but tended to have less shoots (Table 6). It is too early to comment on fruit production with trees in their second year. Generally, the effects of rootstock selections on the tree growth were similar in conventional and organically managed plantings. In both systems of management, AR 481-1 had fewer shoots and less shoot growth than M.9, whilst AR 120-242 had a

greater girth than M.9. However, there was a large impact of the production system on tree performance. Average shoot number, length and trunk girth were reduced from 14.6, 62.9dm and 7.2cm to10.3, 18.2dm and 5.9cm respectively through the adoption of organic management.

Table 6. Growth in 2004 of Queen Cox trees on rootstocks from the East Malling breeding program planted in spring 2003 and managed under organic conditions. 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 (cm/tree)	Total shoot length (dm/tree)	Total shoot number	Yield (kg/tree)	Yield Class 1 >65 mm (kg/tree)
M.9	5.50	17.5	11.25	0.42	0
AR 486-1	5.62	9.0	5.50	0.25	0
AR 295-6	5.92	24.5	12.50	0.35	0.05
AR 120-242	6.12	11.2	7.25	1.32	0
SED (9 df)	0.523	4.22	1.845	0.689	0.035
LSD (P=0.05)	1.205	9.55	4.173	1.558	0.080
Rootstock effect	n.s.	*	**	n.s.	n.s.

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 EE195 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 for 2004 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 M.27) were analysed separately.

In 2004, the growth and cropping of all selections and M.27 was generally similar although AR 801-11 tended to be more vigorous than M.27 i.e. tended to have a larger girth and greater shoot length (Table 7). AR 360-19 had less shoot length than M.27.

It is expected that the new rootstock selections will confer tree sizes in the M.27-M.9 range. 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 fruit.

Table 7. Growth and cropping in 2004 of Bramley trees on rootstocks from the East Malling breeding program planted in spring 2003. 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)

Rootstock	**Girth (cm/tree)**	**Total shoot length (dm/tree)**	**Total shoot number**	**Yield (kg/tree)**	**Yield Class 1 >80 mm (kg/tree)**
M.27	6.14	20.2	5.80	0.40	0.38
AR 360-19	6.54	10.0	5.00	0.56	0.52
AR 69-7	6.64	14.0	4.40	0.28	0.14
AR 628-2	6.84	11.4	5.20	0.20	0
AR 801-11	7.48	29.0	6.60	0	0
SED (16 df)	0.422	4.40	1.058	0.225	0.217
LSD (P=0.05)	0.894	9.32	2.243	0.477	0.460
Rootstock effect	n.s.	**	n.s.	n.s.	n.s.

Under organic management (Project TF141)

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.

As in the previous year, with the exception of AR 360-19 all stocks had a greater girth measurement in 2004 than M.27 (Table 8). AR 801-11 also had more shoots than M.27 and tended to have a greater shoot length.

The results for AR 801-11 were similar to those obtained in the orchard managed conventionally. It should be borne in mind that any differences in girth measurements may reflect the fact that the control (M.27) trees were one year old when planted and were obtained from a different UK nursery to the two-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. It is anticipated that, as the trees get older, any potential differences due to tree age at planting will diminish. It is interesting to note that trees in the organic orchard had much reduced lengths of shoots (average 6.1dm) compared with those in conventional production (average 16.9dm). Clearly, it will take a number of growing seasons for the trees to establish and produce fruit.

Table 8. Growth in 2004 of Bramley trees on rootstocks from the East Malling breeding program planted in spring 2003 and managed under organic conditions. 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)

Rootstock	**Girth (cm/tree)**	**Total shoot length (dm/tree)**	**Total shoot number**	**Yield (kg/tree)**	**Yield Class 1 >80 mm (kg/tree)**
M.27	4.94	4.80	3.6	0.34	0
AR 360-19	5.08	5.00	2.4	0.20	0
AR 628-2	6.02	4.40	4.0	0.08	0
AR 69-7	6.42	5.20	3.8	0.20	0
AR 801-11	7.84	11.00	6.6	0.22	0
SED (16 df)	0.311	2.505	1.18	0.197	-
LSD (P=0.05)	0.660	5.310	2.50	0.418	-
Rootstock effect	***	n.s. (.08)	*	n.s.	-

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

The trees on PR184 were budded at 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 Quince C rootstock. There was no effect of bud height on tree vigour in 2004, but the higher bud height increased yield efficiency of trees on EMC and C132 rootstocks but not those on BP30.

Trees on C132 tended to have greater trunk girths than EMC although the effect just failed to reach statistical significance at the 5% level (Table 10). Total yield and yield of Class 1 fruit above 65mm (Comice) or between 55-65mm (Conference) was higher on C132 than EMC (Table 9). Cumulative yield of Class 1 fruit above 65mm (Comice) was also significantly higher than for EMC but there was no difference in yield efficiency.

The girths of trees on BP30 rootstocks tended to be greater than those on EMC indicating greater vigour but yield in 2004, cumulative yield and yield efficiency were lower for trees on BP30 rootstocks.

Table 9. Cropping in 2004 of Comice and Conference trees on Quince rootstocks planted spring 1999 (Plot PR 184). (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	Roots tock	Graft height (cm)	Total yield (kg / tree)		Yield Class 1 >65 mm (kg / tree)	
			2004	Cumulative	2004	Cumulative
Comice	EMC	10	8.76	20.52	8.10	17.10
	EMC	25	9.05	22.11	8.14	18.06
	BP30	10	8.38	19.77	8.13	17.85
	BP30	25	8.35	19.36	8.11	17.76
	C132	10	10.73	24.25	10.39	22.36
	C132	25	10.67	22.32	10.29	20.57
Conference	EMC	10	7.05	16.70	0	0.74
	EMC	25	7.74	19.32	0.41	1.04
	BP30	10	4.60	14.34	1.86	3.23
	BP30	25	3.82	14.00	1.29	3.10
	C132	10	8.78	17.97	0.46	1.53
	C132	25	9.06	19.74	0.75	4.52
Overall effect	EMC		8.15	19.66	4.16	9.24
	BP30		6.29	16.87	4.85	10.48
	C132		9.81	21.07	5.47	12.25
SED(95 df)			0.698	1.308	0.542	1.025
LSD (P=0.05)			1.386	2.597	1.075	2.035
Rootstock effect			***	**	*	**

Table 10. Growth in 2004 of Comice and Conference trees on Quince rootstocks planted spring 1999 (Plot PR 184). (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 (cm/tree)**	**Tree Volume 2003 (m^3)**	**Yield efficiency (kg/cm^2)**
Comice	EMC	10	16.85	8.58	0.864
	EMC	25	15.99	9.09	1.086
	BP30	10	17.42	7.41	0.803
	BP30	25	17.25	7.58	0.825
	C132	10	18.40	8.96	0.905
	C132	25	16.00	9.31	1.105
Conference	EMC	10	12.54	4.09	1.313
	EMC	25	12.64	4.64	1.495
	BP30	10	12.98	5.05	1.047
	BP30	25	14.02	6.55	0.776
	C132	10	13.53	5.06	1.210
	C132	25	12.80	5.48	1.429
Overall effect	EMC		14.51	6.60	1.190
	BP30		15.42	6.65	0.863
	C132		15.18	7.20	1.162
SED (95 df)			0.431	0.456	0.0510
LSD (P=0.05)			0.855	1.290	0.1012
Rootstock effect			n.s. (.09)	n.s.	***

Performance of Conference on Quince (EMC and C132) and *Pyrus* (QR708/2) rootstocks

QR708/2 continues to be more vigorous than EMC, as evidenced by a greater girth in 2004, but had lower yield in 2004 and has a lower cumulative yield and yield efficiency. As noted in previous reports, there appears to be an incompatibility between Conference and QR708/2 with the result that 50% of the trees have died.

Statistical analysis of the data was restricted in order to compare EMC and C132 without the effect of missing data values for QR708/2 in the analysis of variance. Analysis of the restricted data showed that C132 was less vigorous than EMC and, although cumulative yield was lower, the yield efficiencies of C132 and EMC were the same (Tables 11 and 12).

Table 11. Growth and cropping in 2004 of Conference trees on Quince (EMC and C132) and *Pyrus* (QR708/2) rootstocks planted spring 1997 (Plot PR 173). (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 2004 (cm / tree)**	**Yield 2004 (kg / tree)**		**Tree Volume 2003 (m^3)**
		Total	**Class 1 >65 mm**	
QR708/2	19.40	2.49	0.26	6.07
C132	13.05	7.38	1.41	2.96
EMC	14.99	9.67	0.62	4.80
SED (13 df)	1.154	1.471	0.366	0.863
LSD (P=0.05)	2.492	3.178	0.791	1.864
Rootstock effect	***	***	*	**

Table 12. Cumulative yield and yield efficiency of Conference trees on Quince (EMC and C132) and *Pyrus* (QR708/2) rootstocks planted spring 1997 (Plot PR 173). (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 1999-04 (kg / tree)		Yield efficiency (kg/cm^2)
	Total	Class 1 >65 mm	
QR708/2	22.2	2.16	0.743
C132	25.7	4.21	1.849
EMC	34.3	4.75	1.902
SED (13 df)	3.76	1.113	0.1193
LSD (P=0.05)	8.19	2.426	0.2599
Rootstock effect	*	n.s. (.08)	***

Performance of Conference and Comice on Quince (Sobu and EMC) and *Pyrus* (Pyrodwarf) rootstocks and on pear scion varieties (Geiser Wildeman, Delbuena and Dolacomi) as rootstocks

The trees planted in this trial in the spring of 2000 were two years old and well feathered. Although the first significant crop was produced in 2002, the effects of rootstock on cropping can only be assessed after a number of years of sustained yields. There appears to be an incompatibility with Sobu with the result that 30% of Comice and 60% of Conference trees have died. Data for Sobu were excluded from the statistical analysis. Although data for Sobu are presented in Tables 13 the SEDs and LSDs provided do not apply to any comparisons between means for Sobu and any other rootstocks.

In comparison with EMC, Pyrodwarf and pear scions as rootstocks, increased trunk girth of Conference and Comice (except Geiser Wildeman and Dolacomi) and all were less yield-efficient (Table 13).

In 2004, yields of Conference pears (total and Class 1 55-65mm) on Pyrodwarf and Delbuena rootstocks were higher than on EMC but on Comice pears, none of the experimental rootstocks provided higher yields than EMC whilst Geiser Wildeman and

Dolacomi produced lower yields (total and Class 1 >65mm). Accumulated yield of Conference pears was increased by Delbuena and tended to be increased by Pyrodwarf. With the exception of Delbuena all experimental rootstocks gave lower cumulative yields (total and Class 1 >65mm) than EMC.

Table 13. Growth (girths) and cropping in 2004 of Conference and Comice trees on Quince (Q) and *Pyrus* (P) rootstocks (including pear scion varieties Geiser Wildeman, Delbuena and Dolacomi as rootstocks) planted spring 2000 (Plot PR 187). (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). Sobu not included in the statistical analysis due to a large number of dead trees

Rootstock	**Girth 2004 (cm/tree)**	**Yield 2004 (kg/tree)**			**Cumulative yield 1999-04 (kg/tree)**		**Yield efficiency (kg/cm^2)**
		Total	**Class 1 55-65mm**	**Class 1 >65 mm**	**Total**	**Class 1 >65 mm**	
Conference							
G Wildeman (P)	17.91	7.16	3.00	0.92	14.54	1.20	0.542
Delbuena (P)	17.48	11.33	5.97	1.42	19.22	1.81	0.858
Dolacomi (P)	18.36	6.48	2.30	1.31	11.92	1.65	0.427
Pyrodwarf (P)	20.18	10.59	5.10	0.87	18.22	0.93	0.576
Sobu (Q)	13.04	5.45	4.29	0.61	13.10	1.86	0.975
EMC (Q)	13.01	5.25	2.99	1.41	13.91	2.15	1.019
Comice							
G Wildeman (P)	17.00	2.22	-	1.93	4.38	3.25	0.151
Delbuena (P)	20.72	8.02	-	7.61	15.17	12.03	0.433
Dolacomi (P)	18.74	4.19	-	3.69	8.56	5.54	0.296
Pyrodwarf (P)	21.53	6.71	-	6.53	11.64	9.34	0.323
Sobu (Q)	16.52	7.03	-	7.30	16.13	13.17	0.717
EMC (Q)	17.19	7.57	-	6.82	19.32	12.85	0.839
Overall effect							
G Wildeman (P)	17.46	4.69	3.00	1.43	9.46	2.23	0.346
Delbuena (P)	19.10	9.68	5.97	4.52	17.20	6.92	0.645
Dolacomi (P)	18.55	5.33	2.31	2.50	10.24	3.60	0.361
Pyrodwarf (P)	20.85	8.65	5.10	3.70	14.93	5.13	0.449
Sobu (Q)	14.78	6.24	4.29	3.96	14.62	7.52	0.846
EMC (Q)	15.10	6.40	2.99	4.12	16.61	7.50	0.929
SED (74 df)	0.909	1.112	0.636	0.678	1.784	1.051	0.0724
LSD (P=0.05)	1.812	2.216	1.295	1.351	3.555	2.094	0.1442
Rootstock effect	***	***	***	***	***	***	***

Performance of EMH (QR 193-16) in a commercial orchard

The performance of EMH, EMA and EMC rootstocks on Concorde and Conference has continued at one commercial orchard in East Kent. As expected, Concorde trees on EMH continue to be less vigorous than on EMA. Surprisingly, Conference trees on EMH continue to be smaller than those on EMC (Table 14). As mentioned in previous reports, EMH is usually more vigorous than EMC, although in hot dry conditions, such as in the south of France, Comice and Conference trees on EMH were smaller than those on EMC. Trees are just coming into crop in the commercial orchard.

Yields (2004 and accumulated) of Concorde on EMH were less than on EMA, although fruit size was similar and EMH was more yield-efficient (Table 15). Lower yields (2004 and accumulated) of Conference were obtained on EMH compared with EMC, and though mean fruit weight was higher for EMH yield efficiency was lower. Previous trials have shown that trees on EMC are more precocious than on EMH, but by the fifth leaf yields on EMH are normally equal to EMC. However, in this trial planted in spring 1997, the yields of Conference on EMC rootstocks continue to exceed (by 4.7 fold in 2004) those on EMH.

Table 14. Girth measurements and cropping of Conference and Concorde pears in 2004 on EMA, EMC and EMH rootstocks in a commercial orchard in East Kent. (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 2004 (cm/tree)**	**Yield 2004 (kg/tree)**	**Mean fruit weight (g)**	**Fruit number/ tree 2004**
Concorde	EMA	23.30	10.12	194.2	53.9
	EMH	17.21	6.56	191.3	35.0
Conference	EMC	18.78	5.59	193.4	30.9
	EMH	15.74	1.20	252.8	5.0
SED (72 df)		0.583	0.820	10.00	4.98
LSD (P=0.05)		1.161	1.635	19.96	9.94
Rootstock effect		***	***	***	***

Table 15. Cumulative yield and cropping efficiency of Conference and Concorde pears on EMA, EMC and EMH rootstocks in a commercial orchard in East Kent. (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 fruit number/ tree 2000-04**	**Yield efficiency by number (number/ cm^2)**	**Cumulative yield 2000-04 (kg/tree)**	**Yield efficiency by weight (kg/cm^2)**
Concorde	EMA	95.1	2.27	16.49	0.391
	EMH	72.2	3.18	12.41	0.532
Conference	EMC	151.3	5.22	20.24	0.700
	EMH	49.1	2.45	7.84	0.387
SED (72 df)		11.69	0.344	1.775	0.0495
LSD (P=0.05)		23.31	0.685	3.539	0.0987
Rootstock effect		***	***	***	***

Conclusions

Apple rootstock trials planted at East Malling

Generally, the rootstocks from the Geneva New York breeding programme have performed well in the trial on Queen Cox. G.902 and G.730 were less vigorous than M.9 but tended to have higher yield efficiency. G.11, G.179, G.202 and G.210 were similar in vigour and yield efficiency to M.9 but G.202 and G.179 had a higher cumulative yield of Class 1 fruit above 65mm. The vigour and yield efficiency of G.30 was similar to MM.106. Five of the Geneva rootstocks have been released for commercial propagation and these include three of those in trial at East Malling (G.11, G.30 and G.202). Tree performance of these rootstock selections has been good in the trial at EMR, but growers need to consider additional potential benefits such as pest and disease resistance/tolerance and to assess performance in trials done elsewhere before deciding on whether to plant in preference to Malling rootstocks. Further information on Geneva (G) and Cornell Geneva (CG) rootstocks should be available through commercial nurseries. No further evaluation of this trial is planned.

The Mondial Gala trial compares three of the rootstocks raised at the Vineland Research Station in Canada with the French Pajam 2 rootstock. At the time of planting in March 2000, the tree quality of these bench grafts was very poor in comparison with the trees on Pajam 2. Currently the number of dead or diseased trees for rootstocks V.1, V.3, V.4 and Pajam 2 is one, five, three and one out of six respectively. Clearly, it is not possible to assess the performance of trees on V.3 rootstock and results for V.4 are based on only 50% of the trees originally planted. It is hoped that V.3 can be included in future trials as in current trials in the USA it has produced moderately dwarfed reasonably yield-efficient trees (Autio *et al*., 2005). V.1 was not considered an outstanding rootstock in USA trials and at EMR V.1 performed similarly Pajam 2. The yield efficiencies of V.1 and V.4 were similar but tended to be lower than for Pajam 2. V.4 was more vigorous than Pajam 2 with a greater number and length of shoots. In view of the tree health problem, the trial will be terminated in the coming winter.

It is too early to make any conclusions from trials planted in 2003 (Plots EE195 and GE182) and 2004 (Plot CE190). However, it is interesting to note the extent of the general suppression of tree growth under organic management.

Pear rootstock trials planted at East Malling

Results with C132, a quince rootstock from the HRI breeding programme, in the two trials at East Malling have been contradictory particularly as regards the vigour of the rootstock in comparison with EMC. In the younger trial, there was no greater dwarfing effect of C132 on either Conference or Comice and, though cumulative yield (total and Class 1 fruit above 65mm) was higher than for EMC and yield efficiency was similar. In an older trial Conference on C132 was slightly more dwarfing than EMC and though cumulative yield was lower the yield efficiencies of C132 and EMC were the same. Tree density may be a factor influencing the comparative vigour of Conference on the different stocks. In the older trial, the trees were more densely planted than in the younger trial.

BP30 (a promising Swedish Quince selection) has proved more vigorous than EMC but yield in 2004, cumulative yield and yield efficiency were lower.

QR708/2, a dwarfing *Pyrus* selection from the EMR programme, continues to be more vigorous than EMC but has a lower cumulative yield and yield efficiency and appears to be incompatible with Conference with the result that 50% of the trees have died.

Pyrus scion varieties (Geiser Wildeman, Delbuena and Dolacomi) as rootstocks for Conference and Comice were generally more vigorous and less yield-efficient than EMC and gave lower cumulative yields.

Contrary to expectations, the *Pyrus* rootstock 'Pyrodwarf' has proved more vigorous than EMC and is less yield-efficient, although in 2004 'Pyrodwarf' produced higher yields (total and Class 1 55-65mm) of Conference pears than EMC.

There is an incompatibility problem with the Quince rootstock Sobu and as a result 30% of the Comice and 60% of the Conference trees have died.

In a commercial orchard in East Kent Concorde trees on EMH continue to be less vigorous than on EMA and surprisingly Conference trees on EMH continue to be

smaller than those on EMC. Yields of Concorde on EMH were lower than on EMA although EMH was more yield-efficient. Yields of Conference on EMH were lower (by 84%) compared with EMC although, not surprisingly, mean fruit weight was higher for EMC.

Technology Transfer

An overview of the pear rootstock trialling being undertaken within project TF 134 was presented at the HDC Pear Research Walk at EMR on 26 August 2004.

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