	East Malling Rootstock Club
Project number:	TF 182a (extension of TF 182)
Project leader:	Ms Felicidad Fernández, East Malling Research
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Location of project:	East Malling Research
Project coordinator:	Mr Nigel Kitney
Date project commenced:	1st April 2008
Date project completed (or expected completion date):	31st March 2015

DISCLAIMER

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.

Ms Felicidad Fernández
Project Leader
East Malling Research

Signature .... Date .....31/08/2014........................

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GROWER SUMMARY

Headline

East Malling Research (EMR) continues the development of improved rootstocks for apple and pear through breeding and trialling.

Background and expected deliverables

Improved rootstocks are essential for profitable and sustainable production in tree-fruit crops. Factors important to growers include dwarfing (to reduce the cost of pruning and picking), induction of precocious and reliable cropping, freedom from suckers, good anchorage and resistance to pests and diseases. Ease of propagation and good scion-stock compatibility are also important in the nursery.

In 2008, EMR, the HDC and the International New Varieties Network (INN) launched a Rootstock Club (EMRC) to breed, develop, distribute and commercialise new rootstock breeding material from EMR, world-wide.

For UK growers, the HDC involvement in the development of new rootstocks from EMR's programme, will ensure material will be available to UK levy payers. The HDC helps to 'steer' breeding objectives to meet the specific requirements of UK growers and ensures that appropriate newly selected rootstocks are trialled further before release to the UK industry.

INN has members in the USA, Chile, South Africa, Australia, New Zealand and throughout Europe. In each country, members can produce virus-free (VF) certified rootstocks and premium quality VF certified finished trees. INN members will arrange, evaluate and select from their own trials to identify those rootstocks best suited to each country's specific growing conditions.

The EMRC aims to develop a range of apple, pear and quince rootstocks to suit different growing conditions. Breeding objectives include:

- new dwarfing and semi-dwarfing stocks for apple and pear
- improved scion-graft compatibility, in particular for pear
- increased precocity and productivity
- increased fire-blight and/or woolly apple aphid resistance

- enhanced tolerance to replant disease

Summary of the project and main conclusions

Crossing programme

- Nineteen apple and four pear crosses were carried out in May 2013, of which 13 and two respectively were successful in producing seed.
- Seed from 13 of the apple crosses was sown in January 2014. Germination rates from these seed lots was variable, however an overall germination rate of 85% was achieved resulting in progeny that will be planted in a field plot in June-July 2014.
- Seed from two of the pear crosses was extracted and stored for sowing in 2015.

Seedling populations

- A total of 211 apple seedlings from six families (2,012 crosses) and 556 pear seedlings from four families (2010-12 crosses) were planted in August 2013.
- Apple families planted in 2012 were budded in August 2013.

Selection and propagation

- Field records (vigour, crop load and suckering) were taken on eight apple and three pear families in 2013.
- Three tentative selections were made in September 2013 from apple family M580 (unclear pedigree), with an expectation that they will be taken forward for propagation in 2014 if the good yields recorded in 2013 are repeated.
- Thirteen selections were made in September 2013 from three pear families that were planted in 2006: six from PQ42 (OHxF 51 x *P. amygdaliformus*), four from PQ43 (OHxF 69 x *P. amygdaliformus*) and three from PQ44 (OHxF 333 x *P. betulifolia*).
- Propagation of 47 apple selections and seven pear selections that are already progressing through the rootstock club continued in December 2013. The use of the 'collar system', first utilised in 2012, has proved to be successful in increasing the numbers and quality of suckers produced.
- Re-propagation of the East Malling apple germplasm collection continued in 2013-14 with grafting completed in February 2014.

Pest and disease screening

- Seven apple selections were screened for fire-blight resistance in 2013, with AR295-6 performing better than all the other selections with less than 50% necrosis.

- Woolly apple aphid screen was carried out on 12 apple selections, but colonies did not thrive, leading to inconclusive results.

Preliminary results

- Winter and harvest records were taken from the RF185 trial. This trial was planted with replicates of four selections from apple family M306 (AR86-120 x M20) in 2012. Significant differences in girth measurements were observed.
- The evaluation of two trials of rootstocks for pear planted in 2006 (DM177 & DM178) continued in 2013. Of the Pyrus rootstocks (DM177), three selections, PQ34-1, PQ34-3 and PQ34-6, continued to perform comparably to EMA. In the quince rootstock trial (DM178) showed seven selections of interest in terms of vigour and yield although conclusions on significance are difficult to draw due to low replication.

Financial benefits

- There are major financial implications of developing and selecting rootstocks with improved agronomic performance, including reduced pruning and picking costs and the ability to grow material with reduced pest and disease susceptibility.

Action points for growers

- There are no action points to highlight at this stage of the project.

SCIENCE SECTION

Background

Improved rootstocks are essential for profitable and sustainable production in tree-fruit crops. Factors important to growers include dwarfing (to reduce the cost of pruning and picking), induction of precocious and reliable cropping, freedom from suckers, good anchorage and resistance to pests and diseases. Ease of propagation and good scion-stock compatibility are also important in the nursery. Whilst there are few international breeding programmes generating tree-fruit rootstocks, East Malling Research (EMR) involvement in rootstock development dates back to its foundation with the subsequent release of the world-famous series of apple rootstocks: M (Malling) and MM (Malling-Merton in collaboration with the, as was, John Innes Horticultural Institution).

In 2008 EMR, the HDC and the International New Varieties Network (INN) launched the East Malling Rootstock Club (EMRC) to breed, develop, distribute and commercialise new rootstock breeding material from EMR, world-wide.

For UK growers, the HDC also acts as the UK licensee for the EMRC with the intention of making new rootstocks released from EMR's programme widely available to UK levy payers. The HDC helps to 'steer' breeding objectives to meet the specific requirements of the UK growers and ensures that newly selected rootstocks are trialled further before release to the UK industry.

INN has members in the USA, Chile, South Africa, Australia, New Zealand and throughout Europe. In each country members can produce virus-free (VF) certified rootstocks and premium quality VF certified finished trees. INN members arrange, evaluate and select from their own trials to identify those rootstocks best suited to each country's specific growing conditions.

It is not unusual for a new rootstock to take 30-35 years to be developed and gain recognition. Selection of parental material, crossing, seedling selection and first stage trialling, which are carried out at EMR, takes around 10 years. Promising material is then propagated and released for HDC-funded trials in the UK and INN-funded trials at appropriate sites around the rest of the world. As trial results accumulate, validating which selections are most promising, these rootstocks are then propagated to build up sufficient material for distribution before it is possible to co-ordinate effective world-wide release.

The EMRC will complete the evaluation of apple, pear and quince rootstock material developed by the former APBC currently in the pipeline, with the aim of identifying a range of apple, pear and quince rootstocks with desirable size control, precocity and productivity, with resistance to diseases and pests where applicable.

Aims and objectives

The EMRC aims to develop a range of apple, pear and quince rootstocks to suit different growing conditions. Breeding objectives include:

- new dwarfing and semi-dwarfing stocks for apple and pear
- improved scion-graft compatibility, in particular for pear
- increased precocity and productivity
- increased fire-blight and/or woolly apple aphid resistance
- enhanced tolerance to replant disease

General methods

The breeding programme is an ongoing effort of which different steps are briefly described below:

Crossing

Parental genotypes that carry one or more phenotypic traits of interest are selected and a crossing programme is designed aiming to combine those desirable characteristic into the resulting seedlings. Controlled crosses are carried out in spring. First, the anthers of the intended male parent are extracted from unopened blossoms to avoid cross contamination and placed in Petri dishes until they dehisce, releasing their pollen. Pollen is stored in a desiccator at 3 °C, remaining viable for up to 4 years. Secondly, petals and anthers are removed from the flowers of the intended female at the balloon stage and pollen of the chosen male is placed on the receptive stigmas. Fruits are then left to develop and ripen naturally and seeds are carefully extracted after harvest.

Fresh seeds are washed and soaked in water for 2 - 3 days with daily rinses to remove germination-inhibiting compounds. They are then air-dried and stored at 3 °C until the following January.

Raising seedling populations

Seeds are stratified in the cold-store (between 2 and 4 °C) in trays of moist compost and perlite mix for 16 weeks. After this period seed trays, clearly labelled with progeny numbers, are placed in a glasshouse (at ~ 18 °C) for germination. Individual seedlings are potted and labelled as they become large enough to handle safely and grown on for around two months. In their first summer seedlings are planted out in the field and left to establish for a whole growing season.

Field evaluation of rootstock seedlings

In the first winter 1-year-old bare-rooted plants of standard commercial rootstocks are interspersed in the seedling population as controls. Rootstocks M27, M9, M26 and MM106 are used for apple populations and quince rootstock EMA and EMC are used in the pear populations. Both seedlings and controls are budded with the same scion the following summer and left to grow.

For the three to four years of field establishment of each population records are taken for each seedling with regards to vigour and production of suckers, as well as pest and disease incidence in those suckers. As the common scion comes into fruit differences attributable to the rootstocks, such as fruit size and crop load, are also recorded for two seasons and the most promising seedlings are selected for propagation.

Propagation

Interesting seedlings are selected and marked out with tape in the field during the summer and cut back below the budding union the following autumn. To encourage growth of shoots from the rootstock and their subsequent rooting, stumps are earthed-up with compost in the spring and again during the summer. Leaf samples of each selection are taken at this stage to allow for future DNA identification. Pest and disease incidence of the stocks is recorded during the summer and unhealthy selections may be discarded e.g. severe mildew infection or woolly apple aphid (WAA) infestation.

Hardwood cuttings (ideally ~ 30 cm in length) are taken of these selections at the beginning of December and dipped in 0.5% (indole-3-butryic acid) IBA solution for 5 s prior to insertion into a heated cutting bin to a depth of 6 to 8 cm. The cutting bin consists of 30 cm layer of a 1:1 mixture of peat and fine bark over a 5 cm layer of coarse sand. A soil warming cable maintains bed temperature at 25 ^{o}C. Air temperature is cooled via ventilation to the outside. Cuttings are left until rooted and then potted into 2 L pots in late January or early February and grown on in unheated glasshouse. Ease of propagation is also a key selection criterion and recalcitrant selections are discarded.

Preliminary trials

After one or two years of growth in pots, selections are grafted with a common scion (currently cv. Gala for apples and cv. Conference for pears) and established in replicated trials that include standards commercial rootstocks for control purposes.

In these trials tree vigour is assessed by the measurement of tree volume (either in the form of the number and length of shoots for trees < 3 years old, or by the measurement of the height and spread of the tree crown for older trees) and by the recording of trunk girth at 15 cm above ground level. Where appropriate, fresh weights at the time of grubbing are also recorded as a measure of relative vigour.

Total yields and yields of Class 1 fruit (> 65 mm and 55-65 mm) are measured for each tree and cumulative yields and yield efficiencies (kg per cm^2 of cross section) are calculated. Records are taken of tree health, graft compatibility and anchorage.

The best selections after this preliminary evaluation are subsequently propagated to enter further trials funded by HDC (TF 172) in the UK and by INN overseas.

<u>Pest and disease resistance screening</u>

Fire-blight (FB)

Graft-wood of nine EMR advanced selections is sent to LUBERA's nursery in Switzerland for grafting to M9 rootstocks, from there four to eight trees of each genotype are then sent to the Julius Kuehn-Institute (JKI) in Germany to be tested by Dr Klaus Richter's group. The trees are challenged with a mix of *Erwinia amylovora* after every growth event (5-8 times per season) and the percentage of necrotic shoot length is recorded for each individual plant as well as for M9 susceptible controls.

Woolly apple aphid (WAA)

Colonies of *Eriosoma lanigenum* (WAA) collected from the field at EMR are used to challenge rooted cuttings in the glasshouse. Aphids are added to each tree 2-3 times during July and August. Scoring is carried out at the end of the growing season. Individuals will be considered resistant if WAA failed to establish colonies and susceptible if they have succeeded.

Summary of the project and progress made

New seedling populations

Crossing and germination

Spring was rather late in 2013. Following some cold snaps in the late winter trees did not start to flower until mid-late April and crossing in apples carried on into early May. Generally, fruit set was better than in 2011 and 2012, although seed numbers varied greatly depending on the cross. Details of the cross, including the number of fruit collected and number of seed extracted, are shown in Table 1 (apple) and 2 (pear). Pear seed will be stored for sowing in 2015 whilst apple seeds were all sown in Jan 2014.

Table 1. Summary of results from apple crossing 2013

Female	x	Male	Flowers pollinated	Fruit set	Fruits collected	Aborted seed	Seeds extracted
A469-4	x	MH 10.1	14	8	12	10	40
A469-4	x	MH 12.3	2	0	-	-	-
Bud 9	x	Evereste	211	21	24	5	12
Evereste	x	M9	194	109	118	25	345
Evereste	x	Geneva 30	736	18	5	0	12
Geneva 11	x	AR295-6	42	23	21	13	67
Geneva 30	x	M27	172	87	28	75	29
Geneva 30	x	AR295-6	74	32	41	12	171
M27	x	Geneva 11	34	5	20	5	47
M9-A	x	Evereste	217	21	21	21	14
M9EMLA	x	Sally	168	17	17	6	31
MM106	x	Geneva 30	72	13	9	0	39
Torstein	x	M27	104	7	46	54	242
Torstein	x	M9	118	5	35	50	133
Geneva 30	x	AR295-6	74	42	41	0	0
Hibernal	x	MH 10.1	112	1	1	0	3
Hibernal	x	MH 16.7	52	0	-	-	-
Hibernal	x	MH 12.3	52	0	-	-	-
Hibernal	x	MH 14.5	90	0	-	-	-

Table 2. Summary of results from pear crossing 2013

Female	**x**	**Male**	**Flowers pollinated**	**Fruit set**	**Fruits collected**	**Aborted seed**	**Seeds stored**
OH x F87	x	P525-3	381	75	110	121	159
OH x F51	x	Pyronia (2x)	164	11	10	42	50
Pyronia (2x)*	x	P525-3	31	1	0	-	-
P525-3	x	Pyronia (2x)	44	1	0	-	-

*Diploid

In total, 1,182 apple seeds (29 trays) were sown in January 2014 and stratified at 2 °C for 12 weeks. In April 2014 they were transferred to a heated glasshouse under natural lighting. Germination was variable (Table 3) but generally good, 85% overall (Figure 1). Seedlings will be potted up in May 2014 weaned and planted in the field in June-July 2014.

Table 3. Apple seedling germination in 2014

Family	**Cross**	**Year of crossing**	**Seeds**		**Germination**
			Sown	***Trays***	
M573	Bud 9 x Evereste	2013	**12**	1	50%
M574	Evereste x M9	2013	**345**	7	86%
M575	M9A x Evereste	2013	**14**	1	45%
M576	A469-4 x MH 10.1	2013	**40**	1	65%
M577	Evereste x Geneva 30	2013	**12**	1	45%
M578	Geneva 11 x AR295-6	2013	**67**	2	96%
M579	Geneva 30 x M27	2013	**29**	1	49%
M580	Geneva 30 x AR295-6	2013	**171**	4	85%
M581	M27 x Geneva 11	2013	**47**	1	88%
M582	MM 106 x Geneva 30	2013	**39**	1	91%
M583	Torstein x M27	2013	**242**	5	86%
M584	Torstein x M9	2013	**133**	3	95%
M585	M9EMLA x Sally	2013	**31**	1	35%

Figure 1. 2014 apple rootstock seedlings in the glasshouse at EMR

Establishment and budding

A total of 211 new apple seedlings from six progenies (Table 4) were planted in August 2013 in double rows (at the same spacing as in 2012) in plot SP246. Similarly, 556 new pear seedlings from four different progenies were also planted in August 2013 (Table 5) in plot SP247. Of particular interest is family PRP52, not only because of the large number of seedlings it comprises but because it combines dwarf and dwarfing genes, making it ideal for genetic studies. Thus, leaf samples of all seedlings were collected for DNA extraction and a vigour record was taken classing seedlings as dwarf or normal. Additionally, prior to budding in 2014, we will also record internode length in the whole population. Apple families planted out in summer 2012 (Table 6) were budded in August 2013.

Table 4. Apple rootstock seedling population planted in Aug 2013 (Plot SP246)

Family	Cross	Year of crossing	Germination	Planted
M566	Budagovsky 9 x Evereste	2012	2013	17
M567	M27 x Geneva 11	2012	2013	11
M568	Torstein x M27	2012	2013	4
M569	Torstein x M9	2012	2013	11
M570	Geneva 202 op	2012	2013	88
M571	Geneva 11 op	2012	2013	80

NB: op = open pollinated

Table 5. Pear rootstock seedling population planted in Aug 2013 (Plot SP247)

Family	Cross	Year(s) of crossing	Planted	Seedlings
PRP49a	PB11-30 OHxF333	2010	2013	69
PRP50a	OHxF87 x BP1	2010	2013	132
PRP51	OHFx87 x P525-3	2011&12	2013	4
PRP52	B13 x P525-3	2011&12	2013	351

Table 6. Rootstock progenies budded in August 2013 (Plot SP241)

Family	Cross	Year of crossing	Planted in 2012	Budded with
M555a	Geneva 30 op	2009	123	SA544-28
M556a	Ottawa 3 op	2009	85	SA544-28
M559a	Bud 9 x M9	2010	56	SA544-28
M560a	AR86-1-20 x Geneva 11	2010	183	SA544-28
M561	M27 x Geneva 30	2010	6	SA544-28
M562a	MM106 x Geneva 202	2010	181	SA544-28
M563a	MM106 x Bud. 9	2010	67	SA544-28
M564	Geneva 202 x M27	2011	10	SA544-28
M565	Bud 9 x M116	2011	8	SA544-28

Seedling populations in the pipeline and selection

Apple

Records on vigour, crop and presence of suckers continued in the reporting year for seedlings in SC194 [M550 (AR86-1-20 x M9), M551 (M16 x M9) and M552 (White Angel x M9)]. These families were all planted in 2007 and worked with SA544-28 a year later. Selections will be made in these populations after final evaluation in 2014. Records of height and trunk diameter above the graft union were also taken for families planted in 2010 in plot SC198 [M553 (AR86-1-20 x Geneva 202), M554 (MM106 x Geneva 30), M555 (Geneva 30 op) and M556 (Ottawa 3 op)]. Three tentative selections (Table 7) were made from family M580 (unknown pedigree) in plot SC190. However, relatively good yields in 2013 require confirmation so they will be added to the 2014/15 propagation list once crop load is recorded in 2014.

Table 7. Tentative apple selections made in summer 2013

Plot	Selection	Vigour			Crop load				Suckering		
		2010	2011	2012	2010	2011	2012	2013	2010	2011	2012
SC190	**M580-4**	mw	w	mw	0	0	0	ml	-	-	-
SC190	**M580-16**	w	mw	w	0	0	0	ml	+	-	-
SC190	**M580-32**	w	w	mw	0	0	0	m	-	-	+

w = weak, v = vigorous, mw = moderately weak, m = moderate, ml = moderately light, 0 = no crop or no suckers, + = some suckers and ++ = moderate number of suckers

Pear

In this reporting year the evaluation of the pear families planted in 2006 (SC193) was completed. Records were taken of the vigour, incidence of suckering and crop load for families PQ42 (OHxF 51 x *P. amygdaliformus*), PQ43 (OHxF 69 x *P. amygdaliformus*) and PQ44 (OHxF 333 x *P. betulifolia*) in late September 2013. In all, 13 selections were made; six from PQ42, four from PQ43 and three from PQ44 (Table 8).

Table 8. A summary of the characteristics for each of the pear selections

Plot	Selection	Vigour				Fruiting (y/n)		Suckering			
		2010	2011	2012	2013	2012	2013	2010	2011	2012	2013
SC193	**PQ42-11**	m	mv	mv	m	y	n	0	+	0	0
SC193	**PQ42-23**	m	mv	mv	m	n	y	0	0	0	0
SC193	**PQ42-33**	m	m	mv	mv	n	y	0	0	0	0
SC193	**PQ42-47**	mw	mw	w	mw	y	n	0	0	0	0
SC193	**PQ42-50**	mw	mw	mv	m	n	y	0	0	0	0
SC193	**PQ42-138**	w	w	w	w	n	n	++	++	0	0
SC193	**PQ43-34**	m	mw	m	m	n	y	0	0	0	0
SC193	**PQ43-42**	mv	mv	m-mw	mw	n	y	+	0	0	0
SC193	**PQ43-50**	m	mv	mv	mv	n	y	+	0	0	0
SC193	**PQ43-57**	v	mv	m	m	n	y	0	0	0	0
SC193	**PQ44-10**	mw	mw	m	v	n	n	+	+	0	0
SC193	**PQ44-11**	w	w	mw	v	n	y	++	++	0	0
SC193	**PQ44-26**	mw	mw	m	mw	n	n	+	++	++	+

w = weak, v = vigorous, mw = moderately weak, m = moderate, ml = moderately light, 0 = no crop or no suckers, + = some suckers and ++ = moderate number of suckers

Propagation

Pear selections made in 2013 (Table 8) were cut down below the graft union in December 2013 and fitted with plastic rings to retain rooting substrate around the collar (Figure 2). This has been shown to encourage shoot growth from the original root system and collar. It also protects the growing shoots as well as the labels from mechanical damage during the season.

Figure 2. Improved earthing method using plastic rings to keep rooting substrate around the collar area during the growing season.

Propagation continued in winter 2013-14 of all selections currently in the pipeline and a summary of the numbers of cuttings taken from selections at different stages in December 2013 is shown in Tables 9 (pear) and 10 (apple). This includes the first round of cuttings from families selected in 2012. Thanks to the use of collars in 2012 (Figure 2), propagation of selections in the field looks very promising, with a higher number of more vigorous suckers produced than in previous years, some of which already showed nicely-developed roots at the time of lifting. Additionally, the re-propagation of the EM apple germplasm collection started in February 2013 and continued in 2014, with grafting completed by the end of February. Land preparation for the new apple genebank has already started and we expect to plant between Nov 2014 and spring 2015. A plot has also been allocated and ground is being prepared for the mother plants of recent selections to be planted as hedges in 2014.

Table 9. Cuttings taken from pear selections in December 2013

Plot	Selection	Selection year	Number of cuttings			
			Field		Glasshouse	Total taken
			Hardwood	Rooted	Hardwood	
SC185	**PQ41-9**	2012	4	6	-	10
SC185	**PQ41-26**	2012	1	1	-	2
SC185	**PQ41-52**	2012	-	-	-	0
SC185	**PQ41-57**	2012	-	-	-	0
SC185	**PQ41-60**	2012	2	2	-	4
SC185	**PQ41-61**	2012	-	1	-	1
SC185	**PQ41-63**	2012	-	-	-	0

Table 10. Cuttings taken from apple selections in December 2013

Plot	Selection	Selection year	Number of cuttings			
			Field		Glasshouse	Total taken
			Hardwood	Rooted	Hardwood	
SC181	**M430-217**	2010	5	-	-	5
SC181	**M430-249**	2010	3	-	4	7
SC181	**M432-203**	2010	-	7	2	9
SC181	**M432-217**	2010	-	-	32	32
SC181	**M432-243**	2010	-	-	4	4
SC181	**M432-247**	2010	-	6	4	10
SC181	**M432-250**	2010	-	4	25	29
SC183	**M480-3**	2011	-	1	-	1
SC183	**M481-5**	2011	-	-	-	0
SC183	**M481-10**	2011	2	1	2	5
SC183	**M482-11**	2011	5	2	12	19
SC183	**M482-13**	2011	4	4	28	31
SC183	**M482-42**	2011	3	2	10	15
SC183	**M482-44**	2011	7	1	-	8
SC183	**M482-49**	2011	9	6	3	18
SC183	**M482-54**	2011	9	2	10	21
SC183	**M482-65**	2011	4	3	1	8
SC183	**M482-84**	2011	-	5	7	12
SC183	**M482-87**	2011	2	4	3	9
SC183	**M482-110**	2011	-	2	2	4
SC183	**M482-133**	2011	6	1	2	9
SC183	**M482-153**	2011	19	5	25	49
SC183	**M482-158**	2011	24	-	30	54
SC183	**M482-175**	2011	11	6	17	34

Table 10. (Continued)

Plot	Selection	Selection year	Number of cuttings			
			Field		Glasshouse	Total taken
			Hardwood	Rooted	Hardwood	
SC184	**M508-1**	2012	2	12	-	14
SC184	**M508-22**	2012	-	-	-	0
SC184	**M508-41**	2012	-	14	-	14
SC184	**M508-49**	2012	-	4	-	4
SC190	**M509-22**	2012	8	-	-	8
SC190	**M545-50**	2012	-	-	-	0
SC190	**M545-57**	2012	-	5	-	5
SC190	**M545-58**	2012	-	1	-	1
SC190	**M545-145**	2012	3	4	-	7
SC190	**M546-9**	2012	-	11	-	11
SC190	**M546-22**	2012	1	9	-	10
SC190	**M546-110**	2012	5	11	-	16
SC190	**M546-125**	2012	1-	2	-	12
SC190	**M547-1**	2012	13	4	-	17
SC190	**M547-8**	2012	2	16	-	18
SC190	**M547-41**	2012	1	9	-	10
SC190	**M547-72**	2012	1	2	-	3
SC190	**M548-2**	2012	-	4	-	4
SC190	**M549-59**	2012	-	4	-	4
SC190	**M549-83**	2012	-	10	-	10
SC190	**M549-94**	2012	-	7	-	7
SC190	**M549-122**	2012	-	2	-	2
SC190	**M549-146**	2012	-	7	-	7

Screening advanced selections for pest and disease

Fire-blight (FB)

Graft-wood of seven EMR advanced selections (Table 11) was sent to LUBERA's nursery in Switzerland for grafting to M9 rootstocks. Between one and 10 trees of each genotype were then sent to the Julius Kuehn-Institute (JKI) in Germany to be tested for resistance to FB by Dr Klaus Richter's group following repeated inoculation with *E. amylovora* isolates 'Ea797', 'Ea839' and 'Ea951'. The initial inoculation took place on 5 June and it was then repeated weekly for 6 weeks. The percentage of necrotic shoot length was recorded for each individual plant as well as for M9 and Supporter 4 susceptible controls at the end of July

2013 (Table 11). Necrosis severity varied considerably within genotypes but less so than in 2012. Based on 2012 results alone, we would have concluded that all selections tested ranged from susceptible to very susceptible. Taking this year's results also into consideration we can also infer that susceptibility levels for AR839-9 and AR835-11, and possibly AR837-19, are less extreme than for other selections and comparable to M9 and S4.

In addition, AR295-6 performed better than all other selections with 6/7 shoots presenting less than 50% necrosis. This seems to confirm observation of partial resistance in INN sponsored trials. However, this test does not optimally predict field resistance nor does it evaluate the influence of the rootstock genotype on the response of a susceptible scion.

Table 11. Summary of fire blight (FB) resistance screening for nine EMR rootstock genotypes following repeated inoculation with *Erwinia amylovora* isolates 'Ea782', 'Ea797' and 'Ea914' in 2012 and 'Ea797', 'Ea839' and 'Ea951' in 2013

Genotype	2012			2013		
	# of reps	% of necrosis		# of reps	% of necrosis	
		Range	Average		Range	Average
AR10-2-5				9	54.8-100	87.0
AR10-3-9	7	47.1- 100	77.9	6	60.3-85.7	66.2
AR295-6				7	2.6-25.0	10.0
AR680-2				6	65.0-100	82.0
AR809-3	8	16.7 - 100	73.6			
AR835-11	5	4.3 - 95.2	52.5	7	21.0-82.4*	41.7
AR837-19				10	18.2-73.9	44.4
AR839-9	8	1.7 - 100	40.8	1	n.a.	28.6
AR852-3	5	47.1 - 100	80.1			
B24	4	21.1- 100	72.6			
R104	4	53.3 - 100	76.6			
R59	8	58.1 - 100	83.6			
R80	6	19.2 - 100	68.3			
M.9 T337	7	19.2 -100	68.9	6	16.0-100	47.5
Supporter 4				5	52.9-83.3	69.1

* all except one < 50%

Woolly apple aphid (WAA)

Unusually high temperatures in July and early August put trees under unusual stress, increasing the incidence of red spider mite to levels that could not be controlled with predatory mites. Whilst aphid colonies did better than in the previous summer, they did not thrive as we would have liked, partly due to parasites emerging in the population. Results for 2013 and our interpretation of them and those for 2012 are presented in Table 12.

To improve the reliability of the screening in 2014, infested trees will be overwintered in a glasshouse following a relatively short chill period at 4 °C. New colonies will also be introduced from the field. In view of the mild winter in 2013-14, we expect WAA populations to thrive next year.

Table 12. Woolly apple aphid (WAA) inoculation results for 2013 and summary of indexing for 2012 and 2013. Controls underlined

Selection	**# of reps**	**Incidence* 28/08/2013**				**Incidence* 26/09/2013**				**Phenotype 2013**	**Phenotype 2012**
		0	**1**	**2**	**3**	**0**	**1**	**2**	**3**		
AR10-3-9	5	3	2	0	0	1	3	1	0	Susceptible?	Susceptible?
AR69-7******	2	2	0	0	0	2	0	0	0	Resistant?	n.t.
AR295-6	1	1	0	0	0	0	1	0	0	Inconclusive (Sus)	Susceptible
AR628-2	6	4	0	2	0	5	0	0	1	Susceptible?	n.t.
AR682-6	5	3	0	2	0	3	2	0	0	Inconclusive	n.t.
AR801-11	2	1	1	0	0	1	1	0	0	Inconclusive	Susceptible?
AR809-3	4	1	0	3	0	2	1	1	0	Inconclusive	n.t.
AR835-11	2	0	0	2	0	1	0	0	1	Inconclusive	Susceptible?
B24	3	2	1	0	0	3	0	0	0	Resistant	Resistant?
R104	1	0	1	0	0	0	1	0	0	Inconclusive	Inconclusive
M116	6	0	1	0	0	4	2	0	0	Inclusive (Res)	Resistant
M27	2	0	0	2	0	0	2	0	0	Inclusive (Sus)	Susceptible
M306-6	4	3	1	0	0	3	0	1	0	Inconclusive	n.t.
M306-20	4	3	1	0	0	3	0	1	0	Inconclusive	n.t.
M306-79	3	3	0	0	0	1	1	0	1	Susceptible?	n.t.
M306-189	2	2	0	0	0	0	1	1	0	Inconclusive	n.t.

*where 0 = no aphids seen, 1 = a few aphids but no colonies, 2 = small colonies, 3 = medium colonies and 4 = large colonies
**deselected for high susceptibility to canker

Screening for resistance to WAA and FB in the advanced selections is an on-going effort that will continue in 2014. Table 13 summarises results so far and outlines the work plan for 2014. Additionally, selections from families M432, M482, M508, M546, M547 and M549 will be included in the WAA screening as soon as a sufficient numbers of rooted cuttings become available.

Table 13. Advanced selections undergoing pest and disease screening and plans for 2014

Selection number	**Parentage**		**Woolly apple aphid**		**Fire Blight**	
	♀	♂	**Response[3]**	**EMR[4]**	**Response[3]**	**JKI[5]**
AR10-2-5	MM106	M27	?	2014	Susceptible	✓
AR10-3-9	MM106	M27	Susceptible?	2014	Susceptible	✓
AR295-6	Robusta 5	Ottawa 3	Susceptible	✓	Mod tolerant	✓
B24	AR10-2-5	AR86-1-22	Resistant?	2014	Susceptible	✓
R59	AR134-31	AR86-1-22	Susceptible?	2014	Susceptible	✓
R80	AR134-31	AR86-1-22	?	2014	Susceptible	✓
R104	AR134-31	AR86-1-22	?	2014	Susceptible	✓
AR628-2	Ottawa 3	M.M.106	?	2014	Susceptible	
AR680-2	M26	M7	Susceptible?	2014	Susceptible	✓
AR682-6	M26	M.I.793	?	2014	Susceptible	
AR440-1	M25	M27	Susceptible?	2014	?	2015
AR486-1	Ottawa 3	M7	Susceptible?	2014	?	2015
AR801-11	M26	M1	Susceptible	2014	Susceptible?	2015
AR809-3	R80	M26	?	2014	Susceptible?	2015
AR835-11	M.I.793	M9a	Susceptible?	2014	Fairly Sus	✓
AR837-19	M3	M1	?	2015	Fairly Sus	✓
AR839-9	M7	M27	Susceptible?	2015	Mod Tol?	2015
AR852-3	AR362-16	op	Susceptible?	2015	Susceptible	✓
M306-6	AR86-1-20	M20	?	2014	?	2015
M306-20	AR86-1-20	M20	?	2014	?	2015
M306-79	AR86-1-20	M20	?	2014	?	2015
M306-189	AR86-1-20	M20	?	2014	?	2015

[1] Inoculation at EMR of rooted cuttings 1-3 years old
[2] Sent to Dr Klaus Richter (Julius Kuehn-Institute, Germany) through 'Lubera' for FB testing
[3] If known or with'?' if expected due to parentage or unconfirmed
[4] Confirmed EMR (2012 or 2013) or indicating year test is planned for
[5] Confirmed JKI (2012 or 2013) or indicating year test is planned for

Other disease screening

Plant material of a range of Geneva rootstocks has been sourced to compare EMR selections to in experiments to determine susceptibility to *Phytophthora cactorum* and apple replant disease.

Distribution of propagation material for further trialling

Apple

Graft wood of true-to-type R59 and AR809-3 was sent to IFO in February 2013 and again in as requested.

Pear/quince

Based on the preliminary result from the pear trials seven selections, namely PQ5-12, PQ5-13, PQ5-16, PQ5-18 (quince) and PQ34-3, PQ34-6, PQ35-2 (*Pyrus*), were selected in 2012 for propagation with a view to entering them in the next HDC funded rootstock trial. Take was poor in 2012/13 and they were all collected again in Jan 2014 for rooting. Additionally, the EMRC management committee meeting in September 2013 agreed that the same accessions should be sent to CIV (Italy) to initiate the establishment of mother plants. Wood of all but PQ34-6 was provided in 2013 and 2014. Following 2013 trial results, we recommend this list should be slightly amended. Additionally, DNA was obtained from the mother plants of all PQ34 and PQ35 pear selections and compared with a representative tree in plot DM177. All selections of interest were found to be true-to-type in the trial. We have still to finalise a suitable fingerprinting set for quince but work is on-going.

Preliminary trials

Apple (RF185)

This trial, planted in March 2012, compares four selections from the M306 family (AR86-1-20 x M20) grafted with cv. Gala to three control rootstocks: M9, M116 and MM106. Trees were planted in two rows (5 m × 3 m) according to a randomised design (Fig. 3) with guards on M9 at the ends and between blocks; the guards will also act as pollinators, having been worked with cvs. Fiesta and Braeburn. DNA testing was carried out prior to planting to ensure all selections and controls were true to type. No clear signs of rootstock-scion incompatibility were noted in the reporting period.

R1	T1	g/p	Braeburn*	R2	T1	g/p	Fiesta*
R1	T2	1	M306-79	R2	T2	3	M306-20
R1	T3	1	**M116**	R2	T3	3	**MM106**
R1	T4	1	**M9**	R2	T4	3	M306-79
R1	T5	1	M306-6	R2	T5	3	M306-6
R1	T6	1	M306-189	R2	T6	3	**M116**
R1	T7	1	M306-20	R2	T7	3	**M9**
R1	T8	1	**MM106**	R2	T8	3	M306-189
R1	T9	g/p	Fiesta*	R2	T9	g/p	Braeburn*
R1	T10	2	**MM106**	R2	T10	4	M306-6
R1	T11	2	M306-79	R2	T11	4	M306-189
R1	T12	2	M306-189	R2	T12	4	M306-79
R1	T13	2	M306-6	R2	T13	4	**M9**
R1	T14	2	**M9**	R2	T14	4	M306-20
R1	T15	2	**M116**	R2	T15	4	**M116**
R1	T16	2	M306-20	R2	T16	4	**MM106**
R1	T17	g/p	Braeburn*	R2	T17	g/p	Fiesta*

N

Figure 3. Plot plan for new apple rootstock preliminary trial (plot RF185).

Fruit was harvested on this trial for the first time on 4 October 2013 with winter records completed in January 2014. Data from this trial is shown in Tables 14 (a) and (b).

In terms of rootstock effect on tree growth, we have seen significant differences in girth. As in the previous year, M306-6 and M306-20 showed similar trunks to that of MM106 and M116 and M306-79 continue to be in the same group as M9 (in girth as well as yield efficiency) whilst M306-189 was found to have a narrower girth than all the other selections and standards, in fact showing almost no expansion since the 2012 records were taken. It also produced trees with very low tree volume although this result was not found statistically significant due to high variation between replicates.

There was a light crop on these trees with the only statistical significance relating to the higher number of fruit and yield of Class 1 fruit (> 65 mm) produced from the control M9 stock. However, if looking at trends, M306-79 appears to be as productive as M9 although with smaller fruit size, similar to MM106 in this trial but it is too early to draw any firm conclusions from these findings.

Table 14 (a). The effects of apple rootstocks on the growth of Gala apple trees in 2013 (RF185, planted March 2012).

Rootstock	**2013 data**		
	Girth (cm)	**Tree volume (m^3)**	**Yield efficiency (kg/cm^2)**
M306-6	5.6*c*	0.78	0.45*ab*
M306-20	5.8*c*	0.75	0.10*a*
M306-79	4.4*b*	0.58	0.78*b*
M306-189	3.5*a*	0.25	0.48*ab*
M9	4.4*b*	0.45	0.72*b*
MM106	5.4*c*	0.55	0.40*a*
M116	5.5*c*	0.50	0.18*a*
SED (18 d.f.)	*0.32*	*0.19*	*0.18*
Significance	***	*ns*	*
LSD p=0.05	*0.67*	*0.39*	*0.37*

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

Table 14 (b). The effects of apple rootstocks on the yield of Gala apple trees in 2013 (RF185, planted March 2012).

Rootstock	**Mean yield per tree (kg)**			**Mean number of fruit per tree**		
		< 65mm	**Total**	**≥ 65mm**	**< 65mm**	**Total**
M306-6	0.1*a*	0.81	0.91	0.75*a*	8.8	9.5
M306-20	0	0.22	0.22	0a	3.0	3.0
M306-79	0.18*ab*	1.06	1.23	1.5a*b*	11.8	13.2
M306-189	0.06*a*	0.37	0.43	0.5*a*	6.8	7.2
M9	0.44*b*	0.80	1.24	3.25*b*	8.8	12.0
MM106	0	0.90	0.90	0	13.5	13.5
M116	0	0.39	0.39	0	4.0	4.0
SED (18 d.f.)	*0.13*	*0.32*	*0.38*	*0.91*	*3.88*	*4.15*
Significance	*	*ns*	*ns*	*	*ns*	*ns*
LSD p=0.05	*0.26*	*0.68*	*0.79*	*1.9*	*8.15*	*8.72*

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

Pear and quince trial (DM177 and DM178)

The evaluation of two trials of rootstocks for pear planted in 2006 (plots DM177 and DM178) continued in 2013. DM177 and DM178 were harvested on 2 and 3 October 2013, respectively. Both trials include quince rootstock controls EMA and EMC, the latter from two different sources which continue to perform differently. Tables 15 and 16 summarise the results for plots DM177 (Pyrus) and DM178 (Quince), respectively. Yield was moderate at best. Furthermore, most fruit was very elongated falling below the 55 mm 'grade out' and limiting discrimination on those grounds. Tables 16 and 18 illustrate the fluctuation of cropping over the duration of the trial.

Table 15. The effects of Pyrus and Quince (QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2013. (DM177, planted March 2006). Selections discussed in the main text are highlighted and those already in propagation are underlined.

Rootstock	2013 data					Cumulative data (2007-2013)		
	Girth (cm)	Tree Volume (m^3)	Total Yield (kg/tree)	Class 1 fruit (kg/tree) > 65mm	Class 1 fruit (kg/tree) 55-65mm	Total Yield (kg/tree)	Fruit > 65mm (kg/tree)	Yield efficiency (kg/cm^2)
PQ34-1	21.3	16.4	11.9	0.4	4.6	31.4	5.3	2.2
PQ34-2	15.2	8.5	3.3	0.0	0.8	12.3	1.4	1.5
PQ34-3	22.6	16.1	8.9	0.3	3.2	38.4	5.1	2.0
PQ34-4	11.7	3.0	2.9	0.0	0.0	6.1	0.3	0.8
PQ34-5	16.4	9.2	12.9	1.3	7.0	26.6	2.7	2.1
PQ34-6	18.1	10.6	18.9	0.3	6.0	40.6	2.3	2.4
PQ35-1	12.3	4.4	3.8	0.0	0.1	11.6	1.1	1.6
PQ35-2	14.1	3.4	4.2	0.0	0.1	19.0	1.6	1.6
PQ35-3	8.2	1.5	0.1	0.0	0.0	5.6	2.6	4.2
EMA	20.0	16.6	17.3	0.5	7.4	38.8	4.9	2.1
EMC ex Blackmoor	13.7	4.3	12.8	0.2	4.8	24.1	1.7	2.7
EMC ex Keepers	17.4	10.1	14.4	0.0	1.1	8.5	2.1	2.1
SED (38 d.f.)	2.0	3.0	5.0	0.7	4.0	8.5	2.1	0.8
Significance	***	***	***	ns	ns	***	ns	*
LSD p=0.05	4.0	6.1	10.0	1.4	8.0	17.2	5.7	1.6

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

Table 16. The yield pattern of Pyrus and Quince (QA and QC) rootstocks between 2010-13. (Plot DM177). Trees planted March 2006. (*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect). Selections discussed in the main text are highlighted and those already in propagation are underlined.

Rootstock	Total Yield (kg/tree)				
	2010	2011	2012	2013	Cumulative (2007-2013)
PQ34-1	3.6	11.7	1.3	11.9	31.4
PQ34-2	1.0	4.1	2.8	3.3	12.3
<u>PQ34-3</u>	3.0	15.2	4.2	8.9	38.4
PQ34-4	0.5	2.1	0.3	2.9	6.1
PQ34-5	0.3	8.4	2.6	12.9	26.6
<u>PQ34-6</u>	4.5	10.1	0.0	18.9	40.6
PQ35-1	0.4	1.0	4.1	3.8	11.6
<u>PQ35-2</u>	1.2	2.7	0.1	4.2	19.0
PQ35-3	0.0	0.3	4.3	0.1	5.6
EMA	1.9	11.8	2.6	17.3	38.8
EMC ex Blackmoor	0.4	4.5	1.9	12.8	24.1
EMC ex Keepers	2.5	9.7	1.3	14.4	33.1
SED (38 d.f.)	1.3	2.4	4.2	5.0	8.5
Significance	**	***	ns	***	***
LSD p=0.05	2.6	4.9	8.6	10.0	17.2

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

Of the Pyrus rootstocks in DM177, PQ34-3 and PQ34-6 continued to perform comparably to EMA (both are already in the propagation pipeline for further trials) as did PQ34-1. In fact, PQ34-1 and PQ34-3 are not significantly different in vigour to it and PQ34-6 is only slightly more dwarfing. Comparing the cumulative yield data, they are all similar to EMA, with PQ34-3 having almost identical yield and yield efficiency. PQ34-1 has slightly lower total yield, but not significantly so. Additionally, they are all more precocious than EMC, judging by the 2010 harvest and, with the exception of the atrocious season of 2012, they have all performed consistently well.

The best selection of the more dwarfing family is PQ35-2 - it shows a comparable size to EMC. The cumulative yield and yield efficiency are not as good but, as we only have one entry of this selection in the trial, it would be worth looking at it again.

Table 17. The effects of Quince (including QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2013 (DM178, planted March 2006). Selections discussed in the main text are highlighted and those already in propagation are underlined.

Rootstock	2013 data					Cumulative data (2007-2013)		
	Girth (cm)	Tree Volume (m³)	Total Yield (kg/tree)	Class 1 fruit (kg/tree)		Total Yield (kg/tree)	Fruit > 65mm (kg/tree)	Yield efficiency (kg/cm²)
				> 65mm	55-65mm			
PQ5-1	17.8	8.9	14.6	0.0	2.2	32.8	3.5	2.3
PQ5-2	19.1	7.6	16.6	1.0	4.4	40.1	3.7	2.2
PQ5-3	15.7	6.9	10.9	0.0	1.7	31.9	3.2	2.8
PQ5-6	21.4	17.4	24.5	0.3	11.2	52.6	2.6	2.3
PQ5-7	15.7	10.2	13.5	0.0	1.8	25.8	3.6	2.2
PQ5-8	19.3	11.5	24.5	0.0	11.5	46.5	4.5	2.7
PQ5-9	17.6	8.7	16.7	0.2	5.6	29.7	1.6	1.9
PQ5-10	17.7	11.0	12.2	0.0	0.7	25.4	3.0	1.7
PQ5-11	16.1	8.4	8.8	0.0	5.6	17.4	1.2	1.7
PQ5-12	14.3	4.2	9.2	0.0	4.1	19.9	2.2	2.2
PQ5-13	16.0	8.6	16.2	0.6	12.1	39.4	5.2	3.7
PQ5-16	21.6	21.5	22.0	0.0	8.2	46.9	4.0	2.1
PQ5-18	20.6	14.1	19.5	0.6	7.9	46.9	6.1	2.5
PQ5-19	14.1	5.1	9.2	0.1	4.7	20.5	1.3	2.2
PQ5-20	19.0	9.0	21.5	1.2	10.2	43.9	4.5	2.7
PQ5-21	16.1	5.6	15.5	0.0	6.2	31.5	0.9	2.4
PQ5-22	22.1	13.9	21.2	0.0	6.5	51.3	9.3	2.1
EMA	20.3	15.3	18.4	0.6	8.7	45.9	7.6	2.3
EMC ex Blackmoor	15.7	9.3	14.3	0.0	3.0	36.3	4.0	2.9
EMC ex Keepers	17.0	7.0	10.9	0.0	1.3	32.4	4.0	2.0
SED (48 d.f.)	2.4	4.4	5.8	0.8	4.8	10.4	2.3	0.5
Significance	***	***	*	ns	ns	***	***	**
LSD p=0.05	4.8	8.8	11.7	1.6	9.7	20.8	4.5	1.0

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

In the quince plot (DM178), a number of selections appear to be comparable to the control, although conclusions are particularly difficult to reach in this trial due to the very low level of replicates available for many entries. Therefore many comparisons are based on means and trends, in the absence of statistical significance.

- PQ5-6 has the highest cumulative yield in the trial and is only slight more vigorous that EMA (ns) but with a similar amount of > 55mm fruit produced.
- PQ5-8, -18 & -22 all appear to be slightly more dwarfing than EMA and with very similar total yields, both in 2013 and cumulatively. However, fruit size appears generally to be smaller and, in the case of PQ5-22, yield efficiency is lower than in the controls.
- PQ5-12, previously identified as promising, did not crop particularly well this year and whilst it is one of the most dwarfing entries, its cumulative yield so far is disappointing.
- PQ5-13 is one of the most promising dwarfing selections in this trial; with vigour similar to EMC and almost 75% of fruit produced > 55mm (compared with 50% for EMA). It also has the highest yield efficiency of the trial (significantly higher than EMA and EMC Keepers). It also appears to be a consistent cropper with the highest yield in 2012, when most selections produced almost no fruit.
- PQ5-16, also undergoing propagation, performed slightly worse than PQ5-18 in all categories.

Table 18. The yield pattern of Pyrus and Quince (QA and QC) rootstocks in 2010-13. (Plot DM178). Trees planted March 2006. Selections discussed in the main text are highlighted and those already in propagation are underlined.

Rootstock	Total Yield (kg/tree)				
	2010	2011	2012	2013	Cumulative (2007-2013)
PQ5-1	1.3	8.5	3.0	14.6	32.8
PQ5-2	2.6	11.9	1.1	16.6	40.1
PQ5-3	2.7	9.3	3.1	10.9	31.9
PQ5-6	2.6	14.7	1.1	24.5	52.6
PQ5-7	1.3	2.5	3.7	13.5	25.8
PQ5-8	0.1	9.2	0.1	24.5	46.5
PQ5-9	0.9	9.2	0.5	16.7	29.7
PQ5-10	0.5	8.2	2.2	12.2	25.4
PQ5-11	0.4	5.5	1.3	8.8	17.4
PQ5-12	1.1	5.8	0.1	9.2	19.9
PQ5-13	2.2	8.6	5.4	16.2	39.4
PQ5-16	2.8	13.6	0.3	22.0	46.9
PQ5-18	1.8	13.4	1.6	19.5	46.9
PQ5-19	1.4	5.9	0.5	9.2	20.5
PQ5-20	2.1	12.9	1.9	21.5	43.9
PQ5-21	0.8	8.6	0.6	15.5	31.5
PQ5-22	2.5	14.4	4.4	21.2	51.3
EMA	2.6	13.5	3.6	18.4	45.9
EMC ex Blackmoor	2.4	9.0	4.3	14.3	36.3
EMC ex Keepers	1.6	7.6	2.8	10.9	32.4
SED (48 d.f.)	1.40	3.56	2.8	5.8	10.4
Significance	ns	**	ns	*	***
LSD p=0.05	2.82	7.15	5.6	11.7	20.8

*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect

Due to the limitations for accurate statistical analysis, it would be advisable to conclude both trials of rootstocks for pears after collection of harvest and growth records in 2014-15 and include the most promising in further trials in the UK and overseas subject to adequate propagation.

Crossing programme for 2014

Apple

The main aim of the apple programme is to introduce pest and disease resistance into the East Malling breeding lines, with particular emphasis on resistance to fire blight (FB) and woolly apple aphid (WAA), in order to produce resistant, dwarfing and/or semi-dwarfing rootstocks. We also aim to introduce heat tolerance and water use efficiency (WUE) in combination with suitable nursery characteristics and appropriate vigour. In spring 2013 we are aiming to repeat a number of the crosses that were not very successful in the last couple of years, as well as try to incorporate new germplasm into the breeding programme. Likely parents include:

- **M13:** dwarfing rootstock, parent of M27, poorly characterised in resistance to many diseases but likely to be tolerant of replant disease;
- **M116** (MM106 x M27): semi-vigorous (~ to MM106), very resistant to crown and collar rots, WAA resistant, fairly good WUE, low suckering, hard to propagate;
- **A469-4** [Howgate Wonder x (*Malus platycarpa* x M26)]: very resistant to mildew, not very vigorous;
- **AR295-6** (*M. robusta* 5 x Ottawa 3): promising dwarfing selection, WAA susceptible;
- **Hibernal:** tetraploid, very resistant to mildew, easy rooting;
- **Budagovsky 9** (M8 x Krasny Shtandard): selected in Poland, dwarfing (~ M9), precocious, winder hardy, fairly fireblight resistant in the field, collar-rot resistant, moderate resistance to mildew and scab in the nursery;
- **Geneva 11** (M26 x *M. robusta* 5): dwarfing (~ M9), very precocious, good yield efficiency, adequate rooting, low suckering, no burr-knots, fairly resistant to fireblight, moderately WAA resistant;
- **Geneva 30** (M26 x *M. robusta* 5): dwarfing (~ M9), very precocious, good yield efficiency, adequate rooting, low suckering, no burr-knots, fairly resistant to fireblight, moderately WAA resistant;
- **Geneva 202** (M27 x *M. robusta* 5): semi-dwarfing (~ M26, ~ 45-55% of seedling stock), high yield efficiency, WAA resistant; crown rot and fireblight resistant;
- **Hashabi (MH) 10.1, 12.3, 14.5 & 16.7**: very good heat-tolerance, vigorous, productive, some susceptibility to nematodes, highly susceptible to mildew;
- **Evereste:** Ornamental *Malus*, source of fire blight resistance;

- **Torstein:** Scion cultivar, highly resistant to *Phytophthora cactorum;*
- **Novole:** North American accession of moderate to low vigour, reportedly resistant to *P. cactorum* as well as vole damage.

Pear

The main aim of the pear programme is to produce improved, fully compatible *Pyrus* rootstocks with a range of vigour with good pest and disease resistance that are precocious and easy to propagate. It is anticipated that at least two controlled crosses will be carried out using parents from the list below in suitable combinations:

- **OHxF51:** (Old Home x Barlett*), dwarfing rootstock, moderately susceptible to fire-blight;
- **OHxF69:** (Old Home x Bartlett*), dwarfing rootstock;
- **OHxF333:** (Old Home x Bartlett*) semi-dwarfing rootstock of some commercial interest, precocious, promotes early spurring, slightly more dwarf than OHxF 97, reportedly Fireblight resistant/tolerant;
- **BP1:** South African rootstock (parent of QR708); dwarfing, moderate rooting only;
- **BP2:** South African rootstock; not dwarfing but roots reasonably well;
- **BP3:** South African rootstock, similar vigour and better crop than BP2, not easy to propagate (least interesting of the three);
- **P298/18: (**Williams x US309) Fireblight resistant accession, heavy cropping with compact habit / semi-dwarf;
- ***P.serotina* 'Kumloi':** Hardy genotype, donor of resistance to fireblight, pear scab and leaf spot as well psylla;
- **Pyronia:** Pear x quince hybrids; compact habit;
- **Pyrodwarf:** semi-vigorous, fire blight resistant, precocious (yet to flower at EMR).

*previously attributed to Farmingdale. It is now clear, thanks to DNA evidence, that the reported parentage is not possible and Bartlett is the most likely parent. As a result, FB resistance from Farmingdale is not adequately represented in the rootstock genepool – started steps to re-introduce.