Project number:	TF 182 – The East Malling Rootstock Club
Project leader:	Ms Felicidad Fernández, East Malling Research
Key staff:	Mr Adam Whitehouse Mr Gary Saunders Mrs Karen Thurston Ms Laima Antanaviciute
Location of project:	East Malling Research
Project coordinator:	Mr Nigel Bardsley
Date project commenced:	1 April 2008
Date project completed (or expected completion date):	31 March 2012 (extendable until 31 March 2014)
Key words:	

DISCLAIMER:

AHDB, operating through its HDC division seeks to ensure that the information contained within this document is accurate at the time of printing. No warranty is given in respect thereof and, to the maximum extent permitted by law the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

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

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: 10 May 2011

Report authorised by:

Dr Christopher J Atkinson
Head of Science
East Malling Research

Signature ..... Date: 10 May 2011

CONTENTS

GROWER SUMMARY

Headline

- East Malling Research (EMR) continues to develop improved rootstocks for the apple and pear industry.

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. There are few breeding programmes worldwide 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 including M (Malling) and M.M. (Malling-Merton in collaboration with the John Innes Horticultural Institute). As a consequence of the reduction in government funding for 'near-market' research in the 1990's, industry support was required to maintain the programme. Between 1992 and 2007, breeding apple and pear rootstocks formed one of the objectives of the East Malling Apple and Pear Breeding Club (APBC). The Apple and Pear Research Council and more recently the Horticultural Development Company (HDC) were the UK Licensees for the material developed as part of the APBC, which included two new rootstock releases, M.116 for apple and EMH, a quince rootstock for pear.

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.

EMR has a wealth of breeding lines, derived from UK, USA, Canadian and Japanese material, encompassing diverse agronomic variation and a wide range of resistance to various pests and diseases. Defra continues to fund underpinning strategic research at EMR on genetic mapping of rootstocks and the development of molecular markers for pre-selection of key rootstock characters. The programme is strengthened by EMR's diverse collaborators and international contacts.

For UK growers, the HDC also acts as the UK licensee for the East Malling Rootstock Club (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 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.

It can take over 30 years to develop a new rootstock. Selection of parental material, crossing, seedling selection and first stage which are carried out at EMR, and 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. Trials are undertaken to validate 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, 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. New breeding material will be produced taking account of potential climate change scenarios, using a new streamlined system previously developed in an associated project funded by the Department for the Environment, Food and Rural Affairs (Defra).

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

Currently, there are 40 pear selections at different stages of evaluation. Nine apple selections from the EMRC programme have been included in the latest HDC-funded trial planted in February 2010. A further 11 apple and 5 pear progenies are currently at different stages in the selection pipeline. Progress to date:

- 15 apple and 8 pear selections have entered propagation for preliminary trials.
- A further 7 apple seedlings were identified as interesting and cut back for propagation in 2011-12.
- 20 new progenies (14 apple and 6 pear) have been raised thus far.
- 6 new crosses (4 for apple and 2 for pear) were carried out in spring 2011.

Financial benefits

- Financial benefits to the UK industry will arise once new rootstocks from the programme are released

Action points for growers

- No action points have yet arisen as a result of this work.

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 M.M. (Malling-Merton in collaboration with the, as was, John Innes Horticultural Institute).

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 also acts as the UK licensee for the East Malling Rootstock Club (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 will arrange, evaluate and select from their own trials to identify those rootstocks best suited to each country's specific growing conditions.

It can take over 30 years to develop a new rootstock. 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 and currently in the pipeline, with the aim fo identifying a range of apple, pear and quince rootstocks with desirable size control, precocity and productivity, and with resistance to diseases and pests where applicable. New breeding material will also be produced, taking account of potential climate change scenarios, using a new streamlined system previously developed in an associated project funded by the Department for the Environment, Food and Rural Affairs (Defra).

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

Method

The breeding programme is an ongoing effort with a number of different steps 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 are removed from the flowers of the intended female (balloon stage) and pollen of the chosen male 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, one-year-old bare-rooted plants of commercial standards rootstocks are interspersed in the seedling population as controls. Rootstocks 'M.27', 'M.9', 'M.26' and 'M.M.106' 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 of vigour, production of suckers and 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 future DNA identification. Pest and disease incidence of the stocks is recorded during the summer and unhealthy selections can 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 are dipped in 0.5% IBA (indole-3-butryic acid) solution for 5 seconds 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 the 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 litre 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 'Gala' for apples and 'Conference' for pears) and established in replicated trials that include standard 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 one 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.

Summary of the project and progress made

New seedling populations

The EMRC management committee decided at their September 2010 meeting to allocate approximately 25% of the total breeding effort to pear. This will mean that, although pear crosses will be carried out every year, seedlings will only be germinated and planted biennially.

Apple

Seeds from the 2010 crosses were extracted and sown as per method. In general, germination was good with the exception of M561 of which, thus far, only two seedlings have emerged (Table 1). Despite this, we are still on target to plant approximately 1,000 seedlings during summer 2011. Additionally, spare seeds from families M559 to M563 were stored for possible future overseas plantings and as a back-up source of material.

A total of 1,056 new seedlings from four different progenies (Table 2) were planted in 2010. Two of them resulted from control crossings and two were raised from open pollinated seed lots. The increased size of the 2010 population was partly to compensate for the smaller than average population planted in 2009 and partly in response to the concern of Club member regarding the size of previous populations. Additionally, in order to reduce field costs to allow for higher number of seedlings, a tighter planting spacing is being considered for future plantings.

Table 1. Apple rootstock seedling germination in 2011

Family	Cross	Seeds			Germination
		Total	Sown	Trays	
M557	M.116 x M9a	193	**193**	4	53%
M558	Geneva 30 x M.116	156	**156**	3	89%
M559	Bud 9 x M.9	224	**150**	3	77%
M560	AR86-1-20 x Geneva 11	450	**300**	5	94%
M561	M.27 x Geneva 30	1,111	**350**	7	<1%
M562	M.M.106 x Geneva 202	481	**250**	5	96%
M563	M.M.106 x Bud 9	249	**150**	3	96%

Table 2. New apple rootstock progenies planted in 2010

Progeny number	♀		♂		Seedlings planted
	Rootstock	Characteristics	Rootstock	Characteristics	
M553	AR86-1-20	Sibling of M.116 of moderate vigour; waa[1] resistant, productive	Geneva 202	Moderate dwarfing; waa; fireblight resistant; high yield efficiency	**140**
M554	M.M.106	Semi-vigorous, precocious and heavy cropping, good wue[2], waa resistant	Geneva 30	Semi-dwarfing; fireblight and collar rot resistant; precocious and productive	**367**
M555	Geneva 30	Semi-dwarfing; fireblight and collar rot resistant; precocious and productive	o.p.	n/a	**307**
M556	Ottawa 3	Dwarfing, very productive and precocious, winter hardy, fire blight, waa & collar rot resistant.	o.p.	n/a	**242**

[1] waa: woolly apple aphid
[2] wue: water use efficiency

Pear

Pear crossing was very successful in 2010 and 23 trays of seeds from six families were sown on 21 December with the aim fo planting around 700 seedlings in 2011 (Table 3). Additionally, spare seeds from families PRP46 to PRP50 were stored for possible future overseas plantings and as a back-up.

Table 3. Pear rootstock seedling germination in 2011

Family	Cross	Seeds			Germination
		Total	Sown	Trays	
PRP45	PB11-30 x OHxF87	138	**138**	3	90%
PRP46	B14 (open pollination)	211	**100**	2	100%
PRP47	BP1 x *P. betulifolia*	1,402	**250**	5	100%
PRP48	OHxF333 x 'Junsko Zlato'	1,071	**250**	5	97%
PRP49	PB11-30 x OHxF333	295	**150**	3	85%
PRP50	OHxF87 x BP1	537	**250**	5	97%

Two further crosses – (P525-3 x BP1) and ('Junsko Zlato' x OHxF87) – were made but had very poor set with no seeds being produced. These parents will be included again in the 2011 crossing programme.

Seedling populations in the pipeline

In 2010, the evaluation of apple and pear progenies for the EMRC was carried out jointly by Feli Fernández and Adam Whitehouse.

Apple

A total of 348 seedlings from families M550, M551 and M552 planted in 2009, as well as externally purchased control rootstocks of a range of vigour (M.27, M.9, M.26 and M.M.106), were budded in late August with the columnar scion SA544-28. Budding was delayed for almost 10 days to allow the sticks to harden, which was in turn delayed by climatic conditions earlier in the month. Vigour and presence of suckers was recorded for the first time on seedlings in plot SC190 (below), all from the families budded in 2008. Suckers were subsequently removed.

- M545 (M.9 x Geneva 202): 153 seedlings
- M546 (M.9a x JM7): 156 seedlings
- M547 (M.9a x *M. floribunda* 821): 90 seedlings
- M548 (M.13 x Geneva202): 27 seedlings
- M549 (M.13 x JM7): 159 seedlings

All other seedlings in the pipeline (also budded with SA544-28) were also evaluated for vigour, crop load and suckering in August 2010 and de-suckered.

- M480 (M.9 x M.116): 20 seedlings

- M481 (M.9 x Geneva 202): 18 seedlings
- M482 (mixture between M480 and M481 seed): 205 seedlings
- M508 (M.13 x JM7): 61 seedlings
- AR (unknown): 52 seedlings
- M580 (unknown): 39 individuals

Pear

Seedlings from three progenies planted in 2008, plus quince controls EMA and EMC, were budded with 'Concorde' in August 2009:

- PQ42 (OHxF51 x *P. amygdaliformis*): 160 individuals
- PQ43 (OHxF69 x *P. amygdaliformis*): 98 individuals
- PQ44 (OHxF333 x *P. betulifolia*): 27 individuals

Progeny of the following crosses were evaluated in August 2010 and records taken of their vigour, incidence of suckering and, if appropriate, crop load: PQ40 (OHxF51 x Kumloi), PQ41 (OHxF34 x Kumloi), PQ42 (OHxF51 x *P. amygdaliformis*), PQ43 (OHxF69 x *P. amygdaliformis*), PQ44 (OHxF333 x *P. betulifolia*).

Selection

Apple

Two seedlings out of 83 from progeny M430 (M.I.S x M.27) and five out of 79 from M432 (M.27 x M.116), first identified as promising in 2007, were selected in August 2010 and cut back in January 2011 for propagation in winter 2011-12. The attributes of each selection are shown in Table 4. In general seedlings from the M430 progeny showed greater vigour, hence the lower selection rate.

Table 4. Characterisation of apple rootstock selections made in 2010

Selection number	Vigour			Crop load			Suckering		
	2007	2009	2010	2007	2009	2010	2007	2009	2010
M430-217	mw	mw	mw	m	l[3]	-	+[5]	-[6]	-
M430-249	w[1]	mw	mw	mh	m	-	-	-	-
M432-203	mw	mw	m	h	mh	-	-	-	-
M432-217	mw	mw	w	h	ml	m	-	-	-
M432-243	m[2]	mw	w	m	mh	h[4]	+	+	-
M432-247	mw	mw	m	m	m	mh	-	+	-
M432-250	m	mw	m	-	ml	h	-	-	-

[1]weak, [2]medium, [3]light crop, [4]heavy [5] present, [6] absent

Notes regarding shoot health and vigour were also made on the 2009 selections from the following families currently undergoing propagation:

- M345 (M.M.106 x Totem): 3 selections
- M360 (AR86-1-20 x M.9): 11 selections

Pear

No new selections were made in 2010, but observation notes were made on the selections made in 2009 regarding vigour, health and number of shoots produced.

- PQ38 (QR708-36 OP), 2 selections
- PQ49 (QR517-9 OP), 9 selections

Propagation

Seedlings selected in 2009 were cut back and earthed-up in 2010 to encourage the production of shoots. This will be repeated in spring 2011 to increase the number of replicates per selection, except where seedlings had been subsequently deselected or died.

Apple

In 2008, 10 seedlings from progeny M306 (AR86-1-20 x M.20) were pre-selected for propagation. Of these, three have now been deselected due to severe infestation of woolly apple aphid or severe mildew symptoms. One selection failed to produce any shoots and was also discarded whilst two more produced only very few shoots, so they were cut back again to attempt propagation in 2010-11. Cuttings from the remaining selections were taken in December 2009 and Table 5 shows the number of clones that survived their first growing season. Further cuttings were taken of M306-79 for rooting in 2011 before the seedling field plot was grubbed. As agreed by the EMRC management committee in January 2011, between 5 and 10 replicates of each of the selections shown in Table 3 were grafted with ‘Gala’ in February for the next apple preliminary trial. Bare-rooted M.M.106 (*ex*-FP Mathews), M.116 and M.9 (*ex*-Pépinières du Valois) were also grafted with ‘Gala’ and potted up to be included as standards.

Table 5. Apple rootstock selections: 2009 propagation[1] results and survival; 2011 grafting

Selection	Cuttings taken	Rooting quality[2]				Total 2009	Survival		Number grafted with 'Gala'
		Very good	Good	Fair	Poor		2010	%	
M306-6	24	8	6	3	1	18	14	78	10
M306-20	30	9	5	4	2	20	14	70	10
M306-79	32	2	5	4	2	13	5	38	5
M306-189	23	12	5	2	2	21	16	76	10
M.M.106[3]									10
M.116[4]									10
M.9[4]									10

[1] cuttings were treated with IBA and placed in heated bins for rooting and potted up after 7 weeks
[2] subjective score based on amount and strength (length and diameter) of roots produced
[3] bare rooted *ex* Pépinières du Valois
[4] bare rooted *ex* FP Mathews

Hardwood cuttings of the 14 apple seedlings (3 from M345 and 11 from M360) selected in August 2009 and cut back in December 2009 were taken in January 2011 and treated with IBA to encourage rooting. Results of this propagation, as well as that of M306-79 (repeated from 2009-10), are not yet available.

Pear

Of the 10 seedlings from PQ37 progeny (OHxF87 x B627 (= *P. betulifolia* x *P. calleryana*) that were pre-selected in 2008, two died after being cut back and cuttings were taken from the remaining eight selections in December 2009. Table 6 shows the results of propagation and number of clones that survived their first growing season.

As insufficient numbers of cuttings survived, the establishment of a further pear trial will be delayed by one year. Cuttings from all genotypes were retaken from the field plots and glasshouse collection.

Table 6. Pear rootstock selections: 2009 propagation[1] results and survival

Selection	Cuttings taken	Rooting quality[2]				Total 2009	Survival	
		Very good	Good	Fair	Poor		2010	%
PQ37-1	14	0	1	0	1	2	2	100
PQ37-2	14	0	1	1	8	10	1	10
PQ37-3	14	0	0	3	1	4	3	75
PQ37-4	14	0	0	0	0	0	0	-
PQ37-5	28	0	0	1	4	5	0	0
PQ37-6	10	0	0	2	1	3	0	0
PQ37-7	14	2	1	3	3	9	5	56
PQ37-8	10	0	0	0	4	4	0	0

[1] cuttings were treated with IBA and placed in heated bins for rooting and potted up after 7 weeks.
[2] based on amount and strength of roots produced

1.5. Preliminary trials

Apple

The most recent apple trial (DM169) was grubbed in winter 2008-09 and results were reported to the EMRC. Four rootstocks from this trial were identified for further evaluation in the UK and have been included in the latest HDC-funded trials, planted in March 2010 at EMR. B24, R59 and R104 will be compared to AR852-3, AR839-9, M.9, M.26 and M.27 in a conventionally managed orchard with 'Royal Gala' and 'Braeburn' as scions. R80 has been included in the organic trial alongside AR10-3-9, AR809-3, AR835-11, M.M.106 and M.116, all worked with 'Red Falstaff'.

The fingerprinting carried out on the rootstock advanced selections and material in the pipeline revealed a discrepancy between the R80 genotype maintained at EMR and the plants left-over from propagation for the HDC trial (see 1.6.), suggesting a propagation error. Unfortunately, DM169 was grubbed prior to the discovery of this inconsistency thus the identification of the 'R80' genotypes in this trial can no longer be verified. Additionally, there could be clonal differences between both R80 trees in the EMR genebank as one produced red leaves initially in spring 2010 but the two trees showed no differences in August. Cuttings of all three types were supplied for the establishment of propagating bed at Pépinières du Valois until trial results clarify their usefulness.

Pear

Two trials of rootstocks for pear were evaluated in 2010; DM177 and DF178 (both planted in 2006) including quince rootstocks EMA and EMC as controls. In previous years, it was difficult to see differences between the controls (all EMA were obtained from Blackmoor Nursery, EMC standards were sourced from Blackmoor Nursery and Keepers Nursery). It was expected that the EMC rootstocks obtained from two different nurseries would perform similarly. However, the girths of trees on EMC rootstocks from Keepers Nursery were similar to those of trees on EMA rootstocks and their tree volume was found to be intermediate between that of those on EMA and EMC from Blackmoor.

DM177

Regarding the controls, EMA, EMC ex Blackmoor and EMC ex Keepers, the 2010 and cumulative data showed no statistical differences in yield or yield efficiency. There were significant differences in tree girth and volume between EMA and EMC ex Blackmoor with EMA shown to have the greater vigour. No significant differences in tree girth and volume were found

between EMC ex Keepers and EMA and EMC ex Blackmoor.

- As in 2009, PQ35-3 appears the least vigorous of the new selections although not significantly different than EMC ex Blackmoor, however there is only one PQ35-3 replicate in the plot
- PQ34-2, PQ34-4, PQ35-1, PQ35-2 and PQ35-3 all had significantly less crown volume than EMA
- Two selections PQ34-1 and PQ34-6 had a significantly higher mean total yield per tree than EMC ex Blackmoor in 2010
- Cumulative total yield was significantly greater for PQ34-3 and PQ34-6 than for EMC ex Blackmoor and cumulative total yield was significantly greater for PQ35-2 than for EMA and EMC ex Blackmoor
- Yield efficiency was significantly greater for PQ35-2 than for EMA, EMC ex Blackmoor or EMC ex Keepers

Table 7. The effects of Pyrus and Quince (QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2010. (Plot DM177). Trees planted March 2006. (*, ** and *** indicates rootstock effects significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect)

	2010 data					Cumulative data (2007-2010)		
Rootstock	Girth (cm)	Tree Volume (m^3)	Total Yield (kg)	Class 1 fruit >65 mm (kg/tree)	Class 1 fruit 55-65 mm (kg/tree)	Total Yield (kg/tree)	Class 1 fruit >65 mm (kg/tree)	Yield efficiency (kg/cm^2)
PQ34-1	12.3	3.7	3.6	1.1	0.5	6.6	2.6	0.55
PQ34-2	9.7	2.5	1.0	0.1	0.3	2.1	0.3	0.24
PQ34-3	14.8	4.2	3.0	0.3	1.7	10.1	2.2	0.59
PQ34-4	9.5	2.1	0.5	0.0	0.3	0.9	0.0	0.12
PQ34-5	11.3	3.0	0.3	0.0	0.1	2.9	0.3	0.27
PQ34-6	14.2	5.2	4.5	0.5	2.0	11.6	1.6	0.72
PQ35-1	9.4	1.7	0.4	0.04	0.1	2.6	0.2	0.37
PQ35-2	12.2	2.4	1.2	0.0	0.5	12.0	1.6	1.01
PQ35-3	4.1	0.1	0.0	0.0	0.0	0.9	0.4	0.67
EMA	14.7	5.1	1.9	0.3	0.6	7.1	2.4	0.43
EMC ex Blackmoor	10.8	2.4	0.4	0.0	0.1	4.8	1.2	0.51
EMC ex Keepers	13.8	4.0	2.5	0.1	0.7	7.7	1.6	0.51
SED (38 d.f.)	1.63	1.25	1.31	0.40	0.43	2.43	1.09	0.192
Significance	***	***	**	ns	***	***	**	**
LSD p=0.05	3.31	2.52	2.64	0.82	0.88	4.93	2.21	0.389

DM178

There were no statistically significant differences between any of the controls, EMA, EMC ex Blackmoor and EMC ex Keepers from the 2010 data, or from the 2009 data.

- No selections had a significantly smaller girth or tree volume than EMC ex Blackmoor or

EMC ex Keepers

- None of the selections produced a significantly different crop to EMA, EMC ex Blackmoor or EMC ex Keepers in 2010
- None of the selections had a significantly greater cumulative yield than EMA, EMC ex Blackmoor or EMC ex Keepers
- No selection had a significantly greater yield efficiency than the standards

Table 8. The effects of Quince (including QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2010. (Plot DM178). Trees planted March 2006. (*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect)

Rootstock	2010 data					Cumulative data (2007-2010)		
	Girth (cm)	Tree Volume (m^3)	Total Yield (kg)	Class 1 fruit >65 mm (kg/tree)	Class 1 fruit 55-65 mm (kg/tree)	Total Yield (kg/tree)	Class 1 fruit >65 mm (kg/tree)	Yield efficiency (kg/cm^2)
PQ-1	12.6	2.5	1.3	0.3	0.3	6.7	1.4	0.58
PQ-2	14.1	3.9	2.6	0.3	0.9	10.5	1.6	0.61
PQ-3	11.2	2.9	2.7	0.1	1.5	8.6	1.3	0.86
PQ-6	15.9	5.4	2.6	0.0	1.2	12.3	2.0	0.61
PQ-7	11.2	1.6	1.3	0.0	1.0	6.1	1.4	0.61
PQ-8	13.8	3.5	0.1	0.0	0.1	12.7	2.3	0.84
PQ-9	13.1	3.1	0.9	0.0	0.3	3.3	1.1	0.24
PQ-10	12.7	3.7	0.5	0.1	0.0	2.7	1.1	0.20
PQ-11	10.2	2.3	0.4	0.0	0.2	2.0	0.0	0.21
PQ-12	10.3	1.0	1.1	0.0	0.6	4.9	1.4	0.62
PQ-13	10.9	2.3	2.2	0.6	0.8	9.3	1.8	1.00
PQ-16	15.8	6.2	2.8	0.3	0.9	10.9	2.8	0.56
PQ-18	14.8	4.0	1.8	0.1	0.7	10.3	3.0	0.66
PQ-19	10.6	1.9	1.4	0.4	0.6	5.1	1.0	0.54
PQ-20	13.8	2.8	2.1	0.4	0.8	7.7	2.5	0.48
PQ-21	12.4	3.0	0.8	0.0	0.6	6.8	0.3	0.56
PQ-22	16.5	7.0	2.5	0.6	1.5	11.4	3.7	0.53
EMA	15.0	5.5	2.6	0.3	0.9	10.5	3.1	0.59
EMC ex Blackmoor	11.9	3.2	2.4	0.4	0.9	8.7	3.0	0.73
EMC ex Keepers	13.9	2.8	1.6	0.4	0.4	11.1	3.4	0.74
SED (48 d.f.)	1.91	1.68	1.40	0.45	0.63	3.99	1.54	0.248
Significance	***	**	ns	ns	ns	*	ns	*
LSD p=0.05	3.85	3.37	2.82	0.91	1.27	8.01	3.11	0.499

As for PR180 (1998-2009), the lack of statistically significant differences between the standards (EMA produced at EMR and EMC from a commercial nursery) was originally attributed to the different origins of the rootstocks, but this is now explained by DNA fingerprinting (see section 1.6.). All standards were, in fact, QA and so trial data, including grubbing weights, have been re-analysed. Re-analysis of the data has shown no differences between either the original or subsequent analysis.

1.6. Fingerprinting of advanced selections

1.6.1. Apple

Up to five rooted cuttings of all EMR advanced selections maintained at Pépinières du Valois

were sent to EMR for genetic fingerprinting and comparison with mother trees wherever available. All cuttings were individually labelled and potted up. Leaf samples were collected in spring from those pots as well as from EMR mother trees (Table 9). Leaf samples of genotypes still at Maurice Sarson's nursery were also collected for the purpose of verification (Tables 9 and 10). DNA fingerprinting was carried out according to the recommendations of the *Malus* & *Pyrus* Working Group of the European Cooperative Programme for Genetic Resources (EPCGR) and included DNA control samples provided by INRA's germplasm collection in France (Fernández-Fernández in preparation).

Table 9. Genotypes for 12 Malus SSRs of EMR apple rootstock selections at Pépinières du Valois (Pepival) compared whenever possible to EMR mother trees and/or Sarson's nursery stool beds. Three ECPGR control genotypes (*ex* INRA) were also included. Reference samples are in bold and discrepancies are highlighted. Where all samples from the same provenance produced the same fingerprint only one result is shown

Rootstocks	CH01h01		CH01h10		CH04c07			Hi02c07		CH01f02		CH01f03b		GD12		GD147		CH02c09		CH02c11		CH02d08		CH04e05	
M.9	113	119	96	113	106	114	129	116		168	170	158	170	148	160	139	152	244		213	233	212	254	197	220
M. floribunda 821	103	137	101	109	108			114	136	174	178	148		148	172	-	-	230	250	221	225	214	218	187	197
M. robusta 5	86	97	86	109	106	109		116	118	174	178	170		150	151	-	-	247		203	217	210	212	181	
AR10-2-5_Pepival	119	129	96	113	110	120		114	116	168	180	170		148		139		244	250	205	217	210	212	173	220
AR10-2-5_Pot_EMR	**119**	**129**	**96**	**113**	**110**	**120**		**114**	**116**	**168**	**180**	**170**		**148**		**139**		**244**	**250**	**205**	**217**	**210**	**212**	**173**	**220**
AR10-3-9_Pepival	119	129	96	113	114	120	129	114	116	172	205	136	170	148		131	139	244	254	205	233	224	228	173	220
AR10-3-9_SC181_EMR	**119**	**129**	**96**	**113**	**114**	**120**	**129**	**114**	**116**	**172**	**205**	**136**	**170**	**148**		**131**	**139**	**244**	**254**	**205**	**233**	**224**	**228**	**173**	**220**
AR10-3-9_SC167_EMR	**119**	**129**	**96**	**113**	**114**	**120**	**129**	**114**	**116**	**172**	**205**	**136**	**170**	**148**		**131**	**139**	**244**	**254**	**205**	**233**	**224**	**228**	**173**	**220**
AR120_242_Pepival	129		88	96	110	114	129	114	116	180	205	136	170	148		131	139	244	250	229	233	210	212	173	220
AR120-242_Sarson's	129		88	96	110	114	129	114	116	180	205	136	170	148		131	139	244	250	229	233	210	212	173	220
AR120_242_SC151_EMR	**129**		**88**	**96**	**110**	**114**	**129**	**112**	**114**	**180**	**205**	**136**	**170**	**148**		**131**	**139**	**244**	**250**	**229**	**233**	**210**	**212**	**173**	**220**
AR295-6_Pepival	97	113	86		106	114	129	110	118	170	178	158	170	151	182	139	145	244		203	213	212	214	181	197
AR295-6_Sarson's	97	113	86		106	114	129	110	118	170	178	158	170	151	182	139	145	244		203	213	212	214	181	197
AR295-6_SC151_EMR	**97**	**113**	**86**		**106**	**114**	**129**	**110**	**118**	**170**	**178**	**158**	**170**	**151**	**182**	**139**	**145**	**244**		**203**	**213**	**212**	**214**	**181**	**197**
AR680-2_Pepival	113	119	101		106			110	116	168	178	160	176	148	160	131	147	244		229		224	250	197	208
AR680-2_Sarson's	113	119	101		106			110	116	168	178	160	176	148	160	131	147	244		229		224	250	197	208
AR680-2_SC151_EMR	**113**	**119**	**101**		**106**			**110**	**116**	**168**	**178**	**160**	**176**	**148**	**160**	**131**	**147**	**244**		**229**		**224**	**250**	**197**	**208**
AR801-11_Pepival_1	129		96		110	114	129	116		172	180	136	170	148		139	143	244	254	205	229	210	228	173	
AR801-11_Pepival_2	115		75		94	98	116	100		172	180	136	170	148		139	143	242	252	199	225	204	225	164	
AR801-11_Pepival_3	129		96		110	114	129	116		172	180	136	170	148		139	143	244	254	205	229	210	228	173	
AR801-11_Pepival_4	-	-	-	-	-	-	-	-	-	168	172	136		-	-	-	-	-	-	-	-	-	-	-	-
AR801-11_Pepival_5	113	129	96		112	114	129	116		168	172	138		148		-	-	254		215	227	210	224	173	
AR801-11_Sarson's	113	115	88	101	106	112		114	116	168	182	137	160	148	160	137	139	244		213	215	212	224	197	
AR801-11_SC151_EMR	**113**	**115**	**88**	**101**	**106**	**112**		**114**	**116**	**168**	**182**	**137**	**160**	**148**	**160**	**137**	**139**	**244**		**213**	**215**	**212**	**224**	**197**	
AR839-9_Pepival_1	113	115	88	101	106	112		114	116	168	182	136	160	148	160	137	139	244		213	215	212	224	197	
AR839-9_Pepival_2	113	115	88	101	106	112		114	116	168	182	136	160	148	160	137	139	244		213	215	212	224	197	
AR839-9_Pepival_3	113	115	88	101	106	112		114	116	168	182	136	160	148	160	137	139	244		213	215	212	224	197	
AR839-9_Pepival_4	113	115	88	101	106	112		114	116	168	182	136	160	148	160	137	139	244		213	215	212	224	197	
AR839-9_Pepival_5	113	115	88	101	106	112		114	116	168	182	136	160	148	160	137	139	244		213	215	212	224	197	
AR839-9_Sarson's	119	129	101	113	104	114	129	110	114	168		170	176	148		131	147	240	250	217	229	224	252	208	
AR839-9_SC181_EMR	**119**	**129**	**101**	**113**	**104**	**114**	**129**	**110**	**114**	**168**		**170**	**176**	**148**		**131**	**147**	**240**	**250**	**217**	**229**	**224**	**252**	**208**	
AR835-11_Pepival	117	119	96	113	106	114	129	114	116	170	186	158	178	148		137	139	232	244	213	233	210	254	197	208
AR835-11_SC181_EMR	**117**	**119**	**96**	**113**	**106**	**114**	**129**	**114**	**116**	**170**	**186**	**158**	**178**	**148**		**137**	**139**	**232**	**244**	**213**	**233**	**210**	**254**	**197**	**208**
AR835-11_SC167_EMR	**117**	**119**	**96**	**113**	**106**	**114**	**129**	**114**	**116**	**170**	**186**	**158**	**178**	**148**		**137**	**139**	**232**	**244**	**213**	**233**	**210**	**254**	**197**	**208**
AR852-3_Pepival	109	117	88	101	106	110		114	116	201	203	170		148		139	143	232	254	213		216	224	197	
AR852-3_Sarson's	109	117	88	101	106	110		114	116	201	203	170		148		139	143	232	254	213		216	224	197	
AR852-3_SC167_EMR	**109**	**117**	**88**	**101**	**106**	**110**		**114**	**116**	**201**	**203**	**170**		**148**		**139**	**143**	**232**	**254**	**213**		**216**	**224**	**197**	
AR440-1_Pepival	109	129	96	113	106	114	129	116		168	182	170		148		131	137	232	244	205	233	212	248	208	220
AR837-19_Pepival	119	129	101	113	106	120		106	114	168		170	176	147		131	150	244	250	232		212	252	208	220

SSR results for most selections were in agreement for all samples regardless of their provenance and thus samples from Pépinières du Valois were considered to be true-to-type (TTT). However, all five samples of AR839-9 *ex* Pépinières du Valois turned out to be not-true-to-type (NTTT) and their fingerprinting indicates that they were in fact AR801-11. All samples of

AR801-11 *ex* Pépinières du Valois were also NTTT and corresponded to four different genotypes including AR682-6.

We have recommended the elimination of these stool beds and have since provided new wood for their propagation (see 1.7). No surviving mother trees at EMR or stool beds at Sarson's could be found for two selections (AR440-1 and AR837-19) but all samples provided by Pépinières du Valois for each of them were identical and unique and cuttings sent to EMR will be kept for further characterisation (e.g. woolly apple aphid resistance screening) and to establish mother trees.

Additionally, according to Joris Nicolleau (IFO), material of R59 and R104 is also being maintained in France and samples for fingerprinting are expected in 2011.

Table 10. Genotypes for 12 Malus SSRs of other EMR apple rootstock selections at EMR and/or at Sarson's nursery. Three ECPGR control genotypes (ex INRA, France) also included. Reference samples are in bold and discrepancies highlighted

Rootstocks	CH01h01		CH01h10		CH04c07			Hi02c07		CH01f02		CH01f03b		GD12		GD147		CH02c09		CH02c11		CH02d08		CH04e05	
M.9	113	119	96	113	106	114	129	116		168	170	158	170	148	160	139	152	244		213	233	212	254	197	220
M. floribunda 821	103	137	101	109	108			114	136	174	178	148		148	172	-	-	230	250	221	225	214	218	187	197
M. robusta 5	86	97	86	109	106	109		116	118	174	178	170		150	151	-	-	247		203	217	210	212	181	
AR360-19_Sarson's_1	113	119	113		106	120		114	116	170	205	158	170	148		139	152	244	250	217	233	212		208	220
AR360-19_Sarson's_2	113	119	113		106	120		114	116	170	205	158	170	148		139	152	244	250	217	233	212		208	220
AR360-19 (UN_SC150)	**113**	**119**	**113**		**106**	**120**		**114**	**116**	**170**	**205**	**158**	**170**	**148**		**139**	**152**	**244**	**250**	**217**	**233**	**212**		**208**	**220**
AR86-1-20 _SC150	**119**	**129**	**96**	**113**	**110**	**120**		**114**	**116**	**168**	**180**	**136**	**170**	**148**		**139**	**143**	**244**	**250**	**217**	**229**	**210**	**212**	**173**	**220**
AR86-1-25 $_{(M.116)}$_SC150	**129**		**96**	**113**	**110**	**114**	**129**	**114**	**116**	**168**	**180**	**136**	**170**	**148**		**139**	**143**	**244**	**254**	**217**	**229**	**210**	**212**	**173**	**208**
AR86-1-25_Sarson's_1	119	129	96	113	110	120		114	116	168	182	137	170	148		139	143	244	250	217	229	210	212	173	220
AR86-1-25_Sarson's_2	129		96	113	110	114	129	114	116	168	182	137	170	148		139	143	244	254	217	229	210	212	-	-
AR486-1_Sarson's_1	119		86	96	104	108		106	110	168	170	158	160	147		150		244	247	213	233	214	252	197	
AR486-1_Sarson's_2	119		86	96	104	108		106	110	168	170	158	160	147		150		244	247	213	233	214	252	197	
AR628-2_Sarson's_1	119	129	86	96	108	114	129	110	116	170	180	158	170	148		143	150	247	254	213	229	210	214	173	197
AR628-2_Sarson's_2	119	129	86	96	108	114	129	110	116	170	180	158	170	148		143	150	247	254	213	229	210	214	173	197
AR682-6_Sarson's_1	129		96		110	114	129	116		172	180	136	170	148		139	143	244	254	205	229	210	228	173	
AR682-6_Sarson's_2	129		96		110	114	129	116		172	180	136	170	148		139	143	244	254	205	229	210	228	173	
AR69-7_Sarson's_1	113	119	96	113	106	114	129	116		168	170	158	170	147	160	139	152	244		213	233	212	254	197	220
AR69-7_Sarson's_2	113	119	96	113	106	114	129	116		168	170	158	170	147	160	139	152	244		213	233	212	254	197	220
AR809-3_SC181_1	111	129	96	101	106			116		168	170	158	170	147	160	131	139	244	254	213	215	212	224	173	220
AR809-3_SC181_2	111	129	96	101	106			116		168	170	158	170	147	160	131	139	244	254	213	215	212	224	173	220
AR809-3_GlassHouse_1	111	129	96	101	106			116		168	170	158	170	147	160	131	139	244	254	213	215	212	224	173	220
AR809-3_GlassHouse_2	111	129	96	101	106			116		168	170	158	170	147	160	131	139	244	254	213	215	212	224	173	220
B24_SC181_EMR_26	**111**	**119**	**101**	**113**	**110**	**120**		**114**		**168**	**186**	**136**	**170**	**148**		**139**	**150**	**230**	**250**	**217**	**225**	**210**		**173**	**200**
B24_Sarson's_1	111	119	101	113	110	120		114		168	186	136	170	148		139	150	230	250	217	225	210		173	200
B24_Sarson's_2	111	119	101	113	110	120		114		168	186	136	170	148		139	150	230	250	217	225	210		173	200
R104_SC181_EMR_27	**97**	**129**	**96**	**113**	**114**	**129**		**114**	**116**	**168**	**172**	**170**		**147**		**131**	**139**	**244**	**254**	**205**	**229**	**228**		**173**	**208**
R104_SC181_EMR_28	**97**	**129**	**96**	**113**	**114**	**129**		**114**	**116**	**168**	**172**	**-**	**-**	**147**		**131**	**139**	**244**	**254**	**205**	**229**	**228**		**173**	**208**
R104_M_S Nursery_1	97	129	96	113	114	129		114	116	168	172	170		147		131	139	244	254	205	229	228		173	208
R104_M_S Nursery_2	97	129	96	113	114	129		114	116	168	172	170		147		131	139	244	254	205	229	228		173	208
R59_SC181_EMR	**97**	**129**	**86**	**96**	**108**	**114**	**129**	**114**	**118**	**172**	**178**	**136**	**170**	**147**		**131**	**139**	**244**	**254**	**205**	**233**	**210**	**228**	**173**	**208**
R59_SC181_EMR	**97**	**129**	**86**	**96**	**108**	**114**	**129**	**114**	**118**	**172**	**178**	**137**	**170**	**147**		**131**	**139**	**244**	**254**	**205**	**233**	**210**	**228**	**173**	**208**
R59_Sarson's_1	97	129	86	96	108	114	129	114	118	172	178	137	170	147		131	139	244	254	205	233	210	228	173	208
R59_Sarson's_2	97	129	86	96	108	114	129	114	118	172	178	137	170	147		131	139	244	254	205	233	210	228	173	208
R80_GeneBank_B/53	**119**	**129**	**96**	**101**	**106**	**114**	**129**	**116**		**170**		**158**	**170**	**148**		**139**	**152**	**244**	**254**	**215**	**233**	**212**	**224**	**173**	**220**
R80_GeneBank_B/54	**119**	**129**	**96**	**101**	**106**	**114**	**129**	**116**		**170**		**158**	**170**	**148**		**139**	**152**	**244**	**254**	**215**	**233**	**212**	**224**	**173**	**220**
R80_GH_HDC_1	129		96		112	114	129	116		178	205	170		147		139	150	230	254	205		210	254	181	199
R80_GH_HDC_2	129		96		112	114	129	116		178	205	170		147		139	150	230	254	205		210	254	181	199

Fingerprints for most accessions present in both locations agreed - however, as already mentioned, a disagreement was found between the R80 material propagated for the HDC-funded trial and the mother trees in the EMR genebank. Additionally, one of the M.116 stool beds at Sarson's nursery turned out to be its sister seedling AR86-1-20 instead (Table 10).
It should be noted that the fingerprints for genotypes A106-84, A106-129, A106-135 presented

at the September 2010 meeting are not relevant to the rootstock breeding programme. These were mistakenly sent by the nursery alongside EMR selections.

Samples from the original seedling of all genotypes undergoing propagation at EMR were also fingerprinted for future reference (Table 11).

Table 11. Genotypes for 12 Malus SSRs of all EMR apple rootstock selections currently being propagated for preliminary trials. Three ECPGR control genotypes (ex INRA, France) also included

Rootstocks	CH01h01		CH01h10		CH04c07			Hi02c07		CH01f02		CH01f03b		GD12		GD147		CH02c09		CH02c11		CH02d08		CH04e05	
M.9	113	119	96	113	106	114	129	116		168	170	158	170	148	160	139	152	244		213	233	212	254	197	220
M. floribunda 821	103	137	101	109	108			114	136	174	178	148		148	172	-	-	230	250	221	225	214	218	187	197
M. robusta 5	86	97	86	109	106	109		116	118	174	178	170		150	151	-	-	247		203	217	210	212	181	
M306_006	111	119	96	113	110	120		114	116	168		170	178	148	182	139		232	244	215	229	210		220	222
M306_020	111	129	96	100	110			114	116	168	180	136	158	148		139		232	244	225	229	210	216	173	222
M306_079	111	119	96	113	110	120		114	116	168		158	170	148		139		232	244	225	229	210		173	220
M306_086	113	129	96		96	110		116		168		170	178	148		139	143	238	244	217	225	210		173	222
M306_189	111	129	96	113	96	110		116		168		158	170	148	182	139		232	250	215	217	210	216	173	224
M345_003	117	129	96	107	108	110		110	116	172		170	178	148	151	139	152	254	256	205	233	210	228	173	200
M345_018	107	129	96	109	112	114	129	110	116	172	180	156	170	148	182	139	152	226	244	205	227	214	228	173	200
M345_032	107	129	96	109	108	114	129	114	116	172	180	156	170	148	182	139	152	226	244	205	233	210	214	173	200
M360_009	113	119	96	113	106	110		116		168	180	136	170	148	160	139	143	244	250	217	233	212		173	220
M360_021	119	129	113		114	120	129	114	116	168		136	170	148		139	143	244		217	233	210	254	173	220
M360_034	119		113		106	120		114	116	168	170	136	158	148		139	152	244		217	233	212		197	220
M360_063	113	129	96		106	110		116		168		136	170	148		139	143	244	250	229	233	210	254	173	197
M360_064	113	129	96	113	114	120	129	116		168	170	136	158	148		139	143	244	250	213	229	210	254	173	197
M360_084	113	119	96	113	114	120	129	114	116	168	180	136	158	148	160	139	152	244		217	233	212	254	220	
M360_115	113	129	113		106	120		114	116	168		158	170	148		139	152	244	250	213	217	210	212	197	220
M360_149	119	129	113		110	114	129	116		168		158	170	148		139	152	244	250	213	217	210	212	197	220
M360_163	119	129	113		114	120	129	116		168	170	136	170	148	160	139	143	244	250	213	217	210	254	173	220
M360_172	119	129	96	113	106	120		114	116	170	180	158	170	148		139	143	244		229	233	210	212	197	220
M360_191	113	129	96	113	114	120	129	116		168	170	170		148		139	143	244	250	217	233	210	254	173	220

1.6.2. Pear and quince stocks for pear

Most of the fingerprinting effort was dedicated to clarify the lack of significant differences between the controls of the former preliminary trial in PR180 (Table 12). These tests included samples from all the standard trees formerly in PR180 as well as EMQA and EMQC received or collected from various sources in 2010; EMR hedges, Keepers Nursery in East Farleigh (UK), Pépinières du Valois (France) and CVI (Italy) as well as several other EM quince rootstocks. Unfortunately, a standard protocol is not available for quince. Thus far, we have tested 35 SSR developed from apple and pear and although amplification was generally good polymorphism was low, making genotype discrimination difficult. In fact, only one marker (GD96) could distinguish between QA and QC. However, this is sufficient to conclude that all the standards in PR180 were in fact EMQA explaining the lack of significant differences between them. Further tests will be carried out in 2011 to complete missing values and to improve the protocol for quince fingerprinting. Samples from various quinces such as BA29 and C132 have been requested from INN nurseries to assist in the protocol development.

Similarly, rooted cuttings of all EMR advanced selections maintained at Pépinières du Valois were sent to EMR for genetic fingerprinting and comparison with available mother trees. All

cuttings were individually labelled and potted up. Leaf samples were collected in spring from those pots as well as from EMR mother trees (Table 13). From this analysis however results so far suggest problems with QR530-11 and QR530-4 the later being more problematic as no mother tree survives at EMR.

Furthermore, samples from the original seedlings of all genotypes undergoing propagation at EMR were also fingerprinted, for future reference (Table 14). DNA fingerprinting for *Pyrus* genotypes was straight forward and carried out according to the recommendations of the *Malus* & *Pyrus* Working Group of the European Cooperative Programme for Genetic Resources (EPCGR) and included DNA control samples provided by the UK National Fruit Collection in Brogdale (Evans et al. 2006).

Table 12. Genotypes for 3 *Malus* and 3 *Pyrus* SSRs for quince samples from PR180 trial (identified by row and tree numbers) compared to QA (ex EMR and Keepers Nursery) and QC (ex CIV, Pepival and Keepers Nursery) as well as to other quince accessions from the EMR mother tree plots. Reference samples are in bold and discrepancies highlighted. Missing values (-) will be addressed in 2011

Cydonia rootstocks	Malus SSRs							Pyrus SSRs								
	GD96			CH01d09		CH04e03		EMPc11		KA16				NH29a		
EMQA_Keepers(2010)	**191**	**226**		**122**	**155**	**199**	**201**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EMQA-EMR_1	**191**	**226**		**122**	**155**	**199**	**201**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EMQA-EMR_2	**191**	**226**		**122**	**155**	**199**	**201**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
(EMQA) PR180_1_22	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQA) PR180_2_15	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQA) PR180_3_4	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQA) PR180_4_23	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQA) PR180_5_14	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQA) PR180_6_8	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQC) PR180_1_11	191	226		122	155	-	-	136	140	132	136	138		105	107	136
(EMQC) PR180_2_23	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQC) PR180_3_11	191	226		122	155	199	201	136	140	132	136	138		105	107	136
(EMQC) PR180_4_6	191	226		122	155	-	-	136	140	132	136	138		105	107	136
(EMQC) PR180_5_22	191	226		122	155	-	-	136	140	132	136	138		105	107	136
(EMQC) PR180_6_19	191	226		-	-	199	201	136	140	132	136	138		105	107	136
EMQC_Keepers(2010)	**189**	**191**	**226**	**122**	**155**	**199**	**201**	**-**	**-**	**132**	**136**	**138**		**105**	**107**	**136**
EMQC-CIV	**189**	**191**	**226**	**122**	**155**	**199**	**201**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EMQC-Pepival_1	**189**	**191**	**226**	**122**	**155**	**199**	**201**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EMQC-Pepival_2	**189**	**191**	**226**	**122**	**155**	**-**	**-**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EMQC_Pepival_3	**189**	**191**	**226**	**122**	**155**	**-**	**-**	**136**	**140**	**132**	**136**	**138**		**105**	**107**	**136**
EM_QD-1	191	193	226	122	155	199	201	136	140	132	136	138		105	136	
EM_QD-2	191	193	226	122	155	199	201	136	140	132	136	138		105	136	
EM_QE-1	181	193	226	-	-	188	199	136	140	132	136	138	158	105	136	
EM_QE-2	181	193	226	120	155	188	199	136	140	132	136	138	158	105	136	
EM_QF-1	185	191	226	122	155	190	201	142		132	136	138	158	105	136	
EM_QF-2	185	191	226	122	155	190	201	142		132	136	138	158	105	136	
EM_QG-1	185	191	226	122	155	190	201	142		132	136	138	158	105	136	
EM_QG-2	185	191	226	122	155	190	201	142		132	136	138	158	105	136	
EM_QH-1 (EMH)	191	226		122		190	201	140	142	132	136	138	158	105	136	
EM_QH-1 (EMH)	191	226		122		190	201	140	142	132	136	138	158	105	136	

Table 13. Genotypes for 4 *Malus* and 4 *Pyrus* SSRs for EMR quince rootstock selections at Pépinières du Valois (Pepival) compared whenever possible to EMR mother trees. All quince rootstocks from the EM series except QB, from the EMR mother tree plots have been included for reference. Discrepancies are highlighted. Missing values (-) will be addressed in 2011

Cydonia rootstocks	Malus SSRs															Pyrus SSRs													
	GD96			CH05c06				GD147			CH01d09		CH04e03		EMPc11		EMPc117			KA16				NH29a					
EMQA	191	226		95	107			125	133	157	122	155	199	201	136	140	91	96		132	136	138		105	107	136			
EMQC	189	191	226	95	107			125	133	157	122	155	199	201	136	140	91	96		132	136	138		105	107	136			
EMQD	191	193	226	95	107			125	133	157	122	155	199	201	136	140	91	96		132	136	138		105	136				
EMQE	181	193	226	95	107			125	133	157	120	155	188	199	136	140	91	96		132	136	138	158	105	136				
EMQF	185	191	226	95	109			125	133	157	122	155	190	201	142		91	96		132	136	138	158	105	136				
EMQG	185	191	226	95	109			125	133	157	122	155	190	201	142		91	96		132	136	138	158	105	136				
EMH	191	226		95	109			125	133	157	122		190	201	140	142	91	96		132	136	138	158	105	136				
QR191-3_Pepival 1	191	193		105	107	115		146	156		120	155	188	190	136	142	96			-	-	-	-	-	-	-			
QR191-3_Pepival 2	191	193		105	107	115		144	156		120	155	188	190	136	142	96			-	-	-	-	-	-	-			
QR191-3_Pepival 3	191	193		105	107	115		146	156		120	155	188	190	136	142	96			-	-	-	-	-	-	-			
QR191-3_Pepival 4	191	193		105	107	115		146	156		120	155	188	190	136	142	96			-	-	-	-	-	-	-			
QR191-3_Pepival 5	191	193		105	107	115		146	156		120	155	188	190	136	142	96			-	-	-	-	-	-	-			
QR-196-9_Pepival 1	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR-196-9_Pepival 2	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR-196-9_Pepival 3	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR-196-9_Pepival 4	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR-196-9_Pepival 5	181	185		93	95	104	107	125	133	157	120	155	-	-	136		91	93	96	132	136	138	158	105	136				
QR196-9_EMR_17	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR196-9_EMR_18	181	185		93	95	104	107	125	133	157	120	155	188	199	136		91	93	96	132	136	138	158	105	136				
QR523-1_Pepival 1	181	185		105	107	115		146	156		155		190	199	136	142	96			-	-	-	-	-	-	-			
QR523-1_Pepival 2	181	185		105	107	115		146	156		155		190	199	136	142	96			-	-	-	-	-	-	-			
QR523-1_Pepival 3	181	185		105	107	115		146	156		155		190	199	136	142	96			-	-	-	-	-	-	-			
QR523-1_Pepival 4	181	185		105	107	115		146	156		155		190	199	136	142	96			-	-	-	-	-	-	-			
QR523-1_Pepival 5	181	185		105	107	115		146	156		155		190	199	136	142	96			-	-	-	-	-	-	-			
QR530-11_Pepival 1	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_Pepival 2	185	199		105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_Pepival 3	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_Pepival 4	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_Pepival 5	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_EMR_19	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-11_EMR_20	199			105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-4_Pepival 1	187	199		105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-4_Pepival 2	187	199		105	107	115		156			155		199		136		93			-	-	-	-	-	-	-			
QR530-4_Pepival 3	187	199		105	107	115		156			155		199		136		93			-	-	-	-	-	-	-			
QR530-4_Pepival 4	187	199		105	115			156			155		199		136		93			-	-	-	-	-	-	-			
QR530-4_Pepival 5	187	199		105	115			156			155		199		136		93			-	-	-	-	-	-	-			

Table 14. Genotypes for 12 SSRs of all EMR pear rootstock selections currently being propagated for preliminary trials. Three ECPGR control genotypes (ex NFC, UK) also included

Rootstocks	CH05c06		EMPc117		EMPc11		GD147		CH03d12		CH01d09		GD96		CH02b10		CH03g07		CH01f07a		CH01d08				CH04e03	
Abbe Fetel	87	91	113	115	142	149	125		106	110	149	151	141	150	126		240	243	180	188	286	294			180	198
Hosui	83	103	91	103	140	143	137		97		138	153	175		122	132	248		179	205	247	280	322		188	
Pendula	115	117	91	99	123		131	133	95	103	130	149	169	173	112	138	218	220	182	190	276	296	305		180	
PQ37_1	87	95	97	113	146	149	127		84	106	143	147	159	171	120	138	220	240	183	207	239	253	320		180	184
PQ37_2	87	105	111	117	146	149	127	168	98	106	128	151	157	159	120	138	213	224	183	207	239	245	312		180	190
PQ37_3	87	89	111	113	146	149	127		98	110	147	151	157		130	134	220	224	183	207	253	278	320		190	205
PQ37_4	87	89	97	117	149		127		84	110	128	143	157	159	130	134	220	224	189	207	239	253	320		190	205
PQ37_5	87	105	97	117	149	151	127		84	106	147	151	159	171	120	134	213	240	189	207	245	278	312		180	190
PQ37_6	87	89	111	113	149	151	127		98	110	143	147	157		130	138	220	224	183	207	239	245			180	190
PQ37_7	87	105	97	113	146	149	127		98	106	128	143	157		130	138	213	224	189	207	245	278	312		180	184
PQ37_8	87	105	111	117	149	151	125	127	98	110	143	147	157		130	134	213	224	189	219	239	245	312		180	190
PQ38_1	87		113	117	149	153	125	127	106	130	151	155	141	152	126	136	224	226	180	189	276				180	
PQ38_2	87	91	85	115	149	153	125		123	130	130	147	171	173	118	126	224		175	189	276	300			180	205
PQ39_1	91	107	85	119	140	149	125	131	110		128	163	173		122	126	230	240	175	188	276				180	
PQ39_2	91	99	115		140	142	125	131	110		151	163	152	171	118	130	240		188		279	300			180	
PQ39_3	91	107	115	119	136	149	125	127	123		130	147	152	165	126	130	230	240	175	188	276	279			205	207
PQ39_4	91	97	117	119	138	140	125	131	106		130	155	169	173	122		224	240	188	190	276				205	207
PQ39_5	91	107	115		140	149	125	131	123		147	163	152	165	122	126	224	240	175	180	239	276			205	207
PQ39_6	87	107	115		138	140	125	127	106		155	163	152	169	122		224	240	188	190	279	282			180	205
PQ39_7	97	107	117	119	140	149	125	131	106		130	155	169	173	122	130	240	254	180	190	276				205	207
PQ39_8	83	91	103	115	136	143	131	137	138	140	138	163	173		116	122	240	248	188	199	276	280			180	188

1.7. Germplasm introduction and characterisation

In order to expand the genetic background of our breeding programme we have initiated the

process of introduction of three new apple genotypes from the Cornell Geneva(R) program namely 'G.41', 'G.16' and 'G.935'. Additionally, we have introduced Pyro^{TM}Dwarf, a moderately vigorous and precocious pear rootstock developed in Germany that we plan to include in the forthcoming pear preliminary trial and as a parent for crossing from 2012 onwards.

1.8. Distribution of propagation material from advanced selections

As a result from the fingerprinting exercise it became apparent that stocks of AR839-9 and AR801-11 held by INN nurseries were not true-to-type and therefore 20 graftwood sticks of each were sent to International Fruit Obtention (IFO) as a replacement in February 2011. Propagation material was also sent for all three types of R80: *ex* EMR Gene Bank (row B, tree 53) labelled as GB-Vf80-1; *ex* EMR Gene Bank (row B, tree 54) labelled as GB-Vf80-2 and ex EMR glasshouse (HDC trial propagation) labelled as GH-HDC80 as well as selection B24. Material from AR809-3 was also requested but the hedge had already been pruned and no graftwood was available therefore it will supplied in 2011-12.

1.9. EMRC web page

The EMRC internet site (www.emrootstockclub.com) 'hangs' from EMR's main page and contains a restricted area for club members where contracts, reports and other relevant information is regularly up-dated. To access the members-only area, please contact Feli Fernández (felicidad.fernandez@emr.ac.uk) for a user name and password details.