Project title:	East Malling Rootstock Club
Project number:	TF 182
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Location of project:	East Malling Research
Project coordinator:	Mr Nigel Bardsley
Date project commenced:	1st April 2008
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AUTHENTICATION

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

Ms Felicidad Fernández
Project Leader
East Malling Research

Signature  Date .....29/07/2013.....

Report authorised by:

Prof. Xiangming Xu
Programme Leader
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GROWER SUMMARY

Headline

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

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 M (Malling) and M.M. (Malling-Merton in collaboration with the as was John Innes Horticultural Institution) apple rootstocks. As a consequence of the reduction in government funding for 'near-market' research in the 1990's, industry support for the programme was sought and 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 the East Malling 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 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. 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 15 apple and five 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.
- 30 new progenies (20 apple and 10 pear) have been raised thus far.
- 6 new crosses (4 for apple and 2 for pear) were carried out in spring 2011 and repeated in 2012.

Financial benefits

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

Action points for growers

- At this stage in the project, no action points have been identified.

East Malling Rootstock Club annual report 2012-13

SCIENCE SECTION

Background

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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 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.

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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, together take 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 co-ordinating effective world-

wide release.

The EMRC is completing the evaluation of apple, pear and quince rootstock material developed by the former APBC and 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. 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 in 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 four years. Secondly, petals are removed from the flowers of the intended female at the 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 rootstocks ‘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 of each seedling with regards to 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 season 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 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% (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 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 'Gala' for apples and '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. Fresh weights at the time of grubbing are also recorded as a measure of relative vigour where appropriate.

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.

Pest and Disease resistance screening

Fire-blight (FB)

Graft-wood of nine EMR advanced selections is sent to LUBERA's nursery in Switzerland for grafting to M.9 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 *Erwinia amylovora* isolates 'Ea782', 'Ea797' and 'Ea914' after every growth event and the percentage of necrotic shoot length is recorded for each individual plant as well as for M.9 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 two or three 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

1. Breeding activities

1.1. New seedling populations

1.1.1. Crossing and germination

Unseasonably cool and wet conditions negatively affected fruit set in 2012, resulting in very disappointing seed production from the crossing programme (Table 1). Thus numbers for apple were complemented with open pollinated lots from 'Geneva' accessions maintained in the potted collection alongside a range of rootstocks from the 'M.' and 'M.M.' series as well as several trial selections. As in 2011 with apple families, seed numbers for the pear crosses were complemented with stored seed. When a second lot of seed was being sown from stored seed, family codes were differentiated from the previous population by adding 'a' to the three digit number. Seeds derived from four crosses using Hashabi germplasm only produced four seeds between them, which were not sown but retained to be added to seed from the same crosses that will be repeated in 2013.

In total 27 trays containing 284 apple and 883 pear seeds were sown in January 2013 and stratified at 2°C for 11 weeks. In April 2013 they were transferred to a heated glasshouse under natural lighting. Germination, as of the first week of May (Table 1), was reasonably good and, whilst seedlings are still being potted up, we expect to raise approximately 200 apple and 450 pear seedlings for planting in the 2013 season.

Table 1. Apple and pear rootstock seedling germination in 2012

Species	Family	Cross	Year of	Seeds		Approximate
			crossing	*Sown*	*Trays*	germination
Malus	**M566**	Bud 9 x Evereste	2012	37	1	~ 60%
Malus	**M567**	M.27 x G.11	2012	50	1	~ 25%
Malus	**M568**	Torstein x M.27	2012	6	1	~ 75%
Malus	**M569**	Torstein x M.9	2012	15	1	~ 80%
Malus	**M570**	Geneva 202 o.p.	2012	90	2	> 95%
Malus	**M571**	Geneva 11 o.p.	2012	86	2	> 95%
Pyrus	**PRP49a***	PB11-30 x OHxF333	2010	145	3	~ 70%
Pyrus	**PRP50a***	OHx87 x BP1	2010	287	6	~ 40%
Pyrus	**PRP51**	B617 x P525-3	2011	9	1	~ 75%
Pyrus	**PRP52**	B13 x P525-3	2011	442	9	~ 80%

*seed from these families had also been previously sown in 2010

1.1.2. Establishment and budding

During 2011-12, 729 new apple seedlings were raised and planted in the field in July 2012 (Table 2). A few seedlings were raised from the 'M.27' x 'Geneva 30' seed lot produced in 2010, although they were rather weak. EMR plot SP241 was laid out in double rows with a 50 cm spacing between trees in the row, 1 m spacing within the double row and 3.5 m alleys. These seedlings will be budded with a common scion in August 2013. No pear crossing was planned for 2011-12, so there were no new pear plantings in the reporting year.

Table 2. Apple rootstock seedling population planted in Jul 2012 (Plot SP241)

Family	Cross	Year of crossing	Germination	Planted
M555a	Geneva 30 o.p.	2009	86%	123
M556a	Ottawa 3 o.p.	2009	91%	85
M559a	Bud.9 x M.9	2010	80%	56
M560a	AR86-1-20 x Geneva 11	2010	95%	183
M561*	M.27 x Geneva 30	2010	1%	6
M562a	M.M.106 x Geneva 202	2010	95%	181
M563a	M.M.106 x Bud. 9	2010	93%	67
M564	Geneva 202 x M.27	2011	31%	10
M565	Bud.9 x M.116	2011	100%	8

* N.B.: Seeds from this same crossed failed to germinate in 2011

Families planted out in summer 2011 (Table 3) were budded in August 2012. Following poor bud-take in the apple families in 2011-12, seedlings from the 2010 plantings (EMR plot SC198) that remained unworked were marked in September 2012 and grafted with 'SA544-28' in Dec 2012. They will be evaluated independently of the main population.

Table 3. Rootstock progenies budded in 2012

Plot	Crop	Progeny number	♀	♂	# planted 2011	Budded with
SC199	Apple	**M557**	M116	M9	93	SA544-28
SC199	Apple	**M558**	Geneva 30	M116	114	SA544-28
SC199	Apple	**M559**	Bud 9	M9	110	SA544-28
SC199	Apple	**M560**	AR86-1-20	Geneva 11	242	SA544-28
n/a	Apple	**M561**	M27	Geneva 30	0	-
SC199	Apple	**M562**	M.M.106	Geneva 202	228	SA544-28
SC199	Apple	**M563**	M.M.106	Bud 9	127	SA544-28
SC200	Pear	**PRP45**	PB 11-30	OHxF 87	93	Concorde
SC200	Pear	**PRP46**	B14	o. p.	114	Concorde
SC200	Pear	**PRP47**	BP1	*P. betulifolia*	110	Concorde
SC200	Pear	**PRP48**	OHxF 333	Junsko Zlato	242	Concorde
n/a	Pear	**PRP49**	PB11-30	OHxF 333	0	-
SC200	Pear	**PRP50**	OHxF 87	BP1	228	Concorde

1.2. Seedling populations in the pipeline

1.2.1. Apple

Vigour, crop and presence of suckers were recorded on seedlings in EMR plot SC194. M550 (AR86-1-20 x M.9), M551 (M.16 x M.9) and M552 (White Angel x M.9) families were all planted in 2007 and worked with SA544-28 a year later. No records will be taken of families in plot SC198 until 2013.

1.2.2. Pear

Evaluation continued in plot SC193 of the pear families planted in 2006 (PQ42, PQ43 and PQ44). Records were taken of their vigour, incidence of suckering and crop load, although due to weather conditions in spring few showed any fruit at all.

1.3. Selection

1.3.1. Apple

After three years of evaluation in plots SC184 (M508) and SC190 (AR and M545-549), 22 apple selections were made from the progenies planted in 2006 (M508) and 2007 (AR and M545-549). No selections were made from the M580 family which will be reassessed in 2013. Five selections were made in family M549 (M.13 x JM7), four selections in each of families M545 (M.9 x Geneva 202), M546 (M.9 x JM7) and M547 (M.9 x *M. floribunda* 821), three selections in family M508 (M.13 x JM7) and single selections from each of families AR and M548 (M.13 x Geneva 2020). The main characteristics of each selection are summarised in Table 4.

1.3.2. Pear

Seven new selections were made from the progeny of PQ41 (OH 34 x Kumloi) that had been planted in plot SC185 in 2005. The characteristics of which are shown in Table 5. No selections were made from family PQ40 (OH 51 x Kumloi) as the plants were all considered to be too vigorous.

Table 4. Characterisation of apple rootstock selections made in 2012

Selection number	Vigour[1]			Crop load[2]			Suckering[3]		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
AR-22	w	w	mw	-	-	mh	+	+	-
M508-1	m	m	m	mh	-	h	-	+	++
M508-41	mv	mv	v	-	l	h	-	-	-
M508-49	mw	mw	mw	-	-	l	-	-	+
M545-50	vw	vw	w	-	-	h	+	-	-
M545-57	mw	mw	m	-	ml	h	+	+	-
M545-58	mw	mw	m	-	h	l	++	+	-
M545-145	mw	mw	m	-	l	l	+	+	-
M546-9	mw	mw	w	m	-	mh	-	+	+
M546-22	mw	mw	mw	mh	m	l	-	+	+
M546-110	m	m	m	-	mh	-	+	+	-
M546-125	mw	m/mw	m	-	-	ml	-	-	-
M547-1	m	m	mv	mh	h	-	+++	+++	+
M547-8	mw	mw	m	mh	mh	-	++	++	++
M547-41	w	w	m	mh	m	-	+++	++	+
M547-72	m	m	mv	h	h	-	++	+	-
M548-2	mw	mw	m	-	-	m	++	+	+
M549-59	w	w	mw	h	mh	l	-	-	+
M549-83	m	m	m	m	-	ml	++	+	++
M549-94	w	w	mw	m	-	h	+++	+++	+++
M549-122	mw	mw	mw	ml	l	h	-	-	-
M549-146	m	m	mv	l	ml	ml	-	-	+

[1]where w = weak, mw = medium-weak, m = medium, mv = medium-vigorous and v= vigorous
[2]where vl = very light,l= light, ml = medium-light, m= medium, mh = medium-heavy, h = heavy and vh = very heavy
[3]where – = absent , + = a few present, ++ = several present and +++ = many present

Table 5. Characterisation of apple rootstock selections made in 2012

Selection number	Vigour[1]			Crop load[2]			Suckering[3]		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
PQ41-9	v	-	v	-	-	mh	+	-	+
PQ41-26	m	-	mv	-	-	mh	-	-	-
PQ41-52	v	-	mv	-	-	vh	-	-	-
PQ41-57	m	-	m	-	-	h	-	-	-
PQ41-60	w	-	w	-	-	m	-	-	-
PQ41-61	m	-	v	-	-	m	++	-	++
PQ41-63	mv	-	v	-	-	mh	-	-	-

[1]where w = weak, mw = medium-weak, m = medium, mv = medium-vigorous and v= vigorous
[2]where vl = very light,l= light, ml = medium-light, m= medium, mh = medium-heavy, h = heavy and vh = very heavy
[3]where – = absent , + = a few present, ++ = several present and +++ = many present

1.4. Propagation

Apple and pear seedlings selected in 2012 (Tables 4 & 5) were cut back and earthed up in February 2013 to encourage the production of shoots. Additionally a section of rigid plastic tubing was placed around the base of stems to keep the mix of sand and compost in place.

1.4.1. Apple selections undergoing multiplication for trialling

A total of 32 apple selections are currently at different stages of multiplication for preliminary trials. Additionally, two selections have been dropped due to poor suckering from the original plant and/or failure to root of those cuttings that were taken. Table 6 summarises propagation results from 2011-12 and the availability of potted mother plants in the glasshouse and hardwood cuttings taken for rooting in 2012-13.

1.4.2. Pear selections undergoing multiplication for trialling

A total of 18 pear selections (Table 7) were bulked up for preliminary trials during 2012, of which 13 had mother plant(s) already being maintained in the glasshouse. Survival rate following propagation in Jan 2012 was reasonably good in several selections; 32% on average but ranging from 0-83% and yielding sufficient material to initiate grafting for the next pear preliminary trial.

Ten selections (shaded in Table 7) produced more than four viable cuttings (if a potted mother tree was already available) or more than six (if there was not) and chosen for grafting with ‘Conference’ in February 2013 alongside EMA and EMC quince controls purchased commercially (F.P. Mathews, UK). Additionally, small two-year-old plants were used for PQ37-7 as rooting was poor last year. Cuttings will also be taken for this genotype in order to trial it with comparable plants of other selections (preferred option).

Additionally, the re-propagation of the *Malus* field germplasm collection (gene bank) was initiated in February 2013. Graftwood from 138 accessions, including 50 from 21 different species, was collected and worked on M.26 or M.27 rootstocks (as currently maintained in existing plot). A second round of grafting will be carried out in 2013-14 for those accessions where two or more trees fail to take this year.

Table 6. Overview for EMRC apple selections in propagation

Propagation started	Plot	Apple Selection	HWC* Jan 2012		GH plants 2011&2012	HWC 2012-13	
			Taken	Potted		Taken GH	Taken Field
2009-10	SC177	**M345-18**[1]	0	0	0	-	-
2009-10	SC177	**M345-32**	7	7	4	14	0
2010-11	SC178	**M360-9**	9	7	4	15	0
2010-11	SC178	**M360-21**	2	1	1	1	1
2010-11	SC178	**M360-63**[1]	4	3	0	-	-
2010-11	SC178	**M360-64**	6	0	1	7	4
2010-11	SC178	**M360-84**	9	8	5	10	-
2010-11	SC178	**M360-149**	3	0	0	-	8
2010-11	SC178	**M360-172**[2]	1	1	1	2	-
2010-11	SC178	**M360-191**	4	3	3	8	0
2011-12	SC181	**M430-217**	5	0	0	-	6
2011-12	SC181	**M430-249**	8	6	2	2	6
2011-12	SC181	**M432-203**	8	4	1	3	9
2011-12	SC181	**M432-217**	5	4	4	15	0
2011-12	SC181	**M432-243**	5	0	0	-	1
2011-12	SC181	**M432-247**	6	4	1	2	6
2011-12	SC181	**M432-250**	20	18	9	18	0
2012-13	SC183	**M481-5**	Not applicable				1
2012-13	SC183	**M481-10**	Not applicable				3
2012-13	SC183	**M482-11**	Not applicable				8
2012-13	SC183	**M482-13**	Not applicable				7
2012-13	SC183	**M482-42**	Not applicable				5
2012-13	SC183	**M482-44**	Not applicable				6
2012-13	SC183	**M482-49**	Not applicable				6
2012-13	SC183	**M482-54**	Not applicable				17
2012-13	SC183	**M482-65**	Not applicable				16
2012-13	SC183	**M482-76**	Not applicable				15
2012-13	SC183	**M482-84**	Not applicable				6
2012-13	SC183	**M482-87**	Not applicable				7
2012-13	SC183	**M482-110**	Not applicable				8
2012-13	SC183	**M482-133**	Not applicable				8
2012-13	SC183	**M482-153**	Not applicable				9
2012-13	SC183	**M482-158**	Not applicable				9
2012-13	SC183	**M482-175**	Not applicable				18

* Hard Wood Cuttings
[1] Original seedling dead in the field; selection dropped (green shaded rows)
[2] Original seedling dead in the field but rooted plant available in propagation pipeline (blue shaded rows)

Table 7. Overview for EMRC pear selections in propagation

Propagation started	Plot	Pear Selection	GH plants 2011-12	HWC* Jan 2012		Rootstocks 2013		HWC taken 2013
				Taken	Potted	Available	Grafted	
2009-10	SC176	**PQ37-1**	3	7	4	-	-	10
2009-10	SC176	**PQ37-2**	7	20	18	12	10	-
2009-10	SC176	**PQ37-3**	15	12	12	10	10	-
2009-10	SC176	**PQ37-4**	1	4	2	2	-	-
2009-10	SC176	**PQ37-5**	0	16	16	9	6	-
2009-10	SC176	**PQ37-6**	1	5	1	-	-	-
2009-10	SC176	**PQ37-7**	10	9	9	1	7†	18
2009-10	SC176	**PQ37-8**	3	18	15	12	10	-
2009-10	SC179	**PQ38-1**	1	5	4	-	-	4
2009-10	SC179	**PQ38-2**	0	16	12	9	6	-
2009-10	SC179	**PQ39-1**	4	25	20	12	10	-
2009-10	SC179	**PQ39-2**	7	25	23	2	-	16
2009-10	SC179	**PQ39-3**	12	23	23	15	12	-
2009-10	SC179	**PQ39-4**	1	34	20	9	7	-
2009-10	SC179	**PQ39-5**	0	13	10	6	5	10
2009-10	SC179	**PQ39-6**	4	11	1	-	-	20
2009-10	SC179	**PQ39-7**	19	10	10	4	4	18
2009-10	SC179	**PQ39-8**	0	28	20	4		10

* Hard Wood Cuttings
† 2-year old rootstocks

1.5. Screening advanced selections for pest and disease

As mentioned in our previous report, propagation material was taken in January 2012 from advanced selections currently undergoing HDC-funded trials in the UK in order to determine their response to woolly apple aphid (WAA) and Fire Blight (FB).

1.5.1. Fire-blight (FB)

Graft-wood of nine EMR advanced selections (Table 9) was sent to LUBERA's nursery in Switzerland for grafting to M.9 rootstocks. Between four and eight 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 *Erwinia amylovora* isolates 'Ea782', 'Ea797' and 'Ea914', the percentage of necrotic shoot length was recorded for each individual plant as well as for M.9 susceptible controls (Table 8). Necrosis severity varied greatly within genotypes (Figure 1) and, whilst the mean values suggest a difference in the level of susceptibility, all selections had at least one individual showing > 95% necrosis. Thus, although we are inclined to consider that all the advanced selections tested in 2012 are fully susceptible, field susceptibility could be different.

Table 8. Summary of fire blight (FB) resistance screening for nine EMR rootstock genotypes following repeated inoculation with *Erwinia amylovora* isolates 'Ea782', 'Ea797' and 'Ea914'

Genotype	Number of Repetitions	% of necrosis	
		Range	Average
AR839-9	8	1.7 - 100	40.8
AR835-11	5	4.3 - 95.2	52.5
R80	6	19.2 - 100	68.3
B24	4	21.1- 100	72.6
AR809-3	8	16.7 - 100	73.6
R104	4	53.3 - 100	76.6
AR10-3-9	7	47.1- 100	77.9
AR852-3	5	47.1 - 100	80.1
R59	8	58.1 - 100	83.6
M.9	**7**	**19.2 -100**	**68.9**

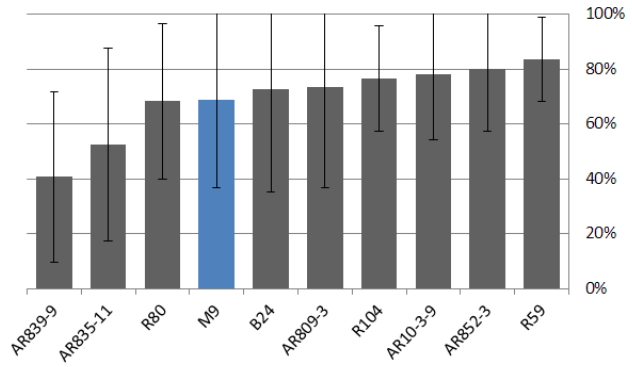

Figure 1. Means and standard deviation of the percentage of necrosis presented by nine EMR rootstock genotypes following inoculation with *Erwinia amylovora* isolates 'Ea782', 'Ea797' and 'Ea914'.

1.5.2. Woolly apple aphid (WAA)

Rooting of HWC was variable and only four advanced selections could be tested. Colonies of *Eriosoma lanigenum* (WAA) collected from the field at EMR were used to challenge rooted cuttings of four apple advanced selections: AR10-3-9 (3 reps), AR835-11 (four reps), B24 (two reps) and R59 (one rep) as well as three plants each of M.116 (resistant) and AR295-6 (susceptible). Despite being maintained in a glasshouse for over three months the aphids did not thrive, probably due to the cool and cloudy summer. Very small colonies could be found in at least one of the plants of all genotypes except M.116 and B24, but the test was not severe enough to consider the latter resistant. Hard wood cuttings were placed in heated bins for rooting at EMR for subsequent inoculation with WAA colonies collected in the field.

Screening for resistance to WAA and FB in the advanced selections is an on-going effort that will continue in 2013 (Table 9).

Table 9. Advanced selections for pest and disease screening 2013

Selection number	Parentage		Woolly apple aphid		Fire blight	
	♀	♂	Response[3]	EMR[1]	Response[3]	JKI[2]
M.116			Res	✓	Sus	
M.27			Sus	✓	Sus	
AR10-2-5	M.M.106	M.27	?		?	✓
AR10-3-9	M.M.106	M.27	Sus?[4]	✓	Sus	✓
AR69-7	AR10-2-6	op	Sus	✓		
AR295-6	Robusta 5	Ottawa 3	Sus	✓	Sus/better than M.26	✓
B24	AR10-2-5	AR86-1-22	?	✓	Sus[5]	
R59	AR134-31	AR86-1-22	Sus?[4]		Sus[5]	
R80	AR134-31	AR86-1-22	?		Sus[5]	
R104	AR134-31	AR86-1-22	?	✓	Sus[5]	
AR628-2	Ottawa 3	M.M.106	?	✓	Sus	
AR680-2	M.26	M.7	Sus		Sus	✓
AR682-6	M.26	M.I.793		✓	Sus	
AR801-11	M.26	M.1		✓	Sus	
AR809-3	R80	M.26	?	✓	?	
AR835-11	M.I.793	M.9a	Sus?[4]	✓	Sus[5]	✓
AR837-19	M.3	M.1	?		?	✓
AR839-9	M.7	M.27	Sus[4]	-	?	✓
AR852-3	AR362-16	op	Sus?		?	
M306-6	AR86-1-20	M.20	?	✓	?	
M306-20	AR86-1-20	M.20	?	✓	?	
M306-79	AR86-1-20	M.20	?	✓	?	
M306-189	AR86-1-20	M.20	?	✓	?	

[1] Inoculation at EMR of rooted cuttings 1-2 years old
[2] Sent to Dr Klaus Richter (Julius Kuehn-Institute, Germany) through 'Lubera' for FB testing
[3] If known or expected due to parentage susceptible
[4] Very small colonies seen in EMR's 2012 screen
[5] JKI 2012 screen

1.6. Distribution of propagation material for further trialling

1.6.1. Apple

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

1.6.2. Pear/Quince

Based on the preliminary result from the pear trials, Gary Saunders (EMR) requested hardwood cuttings of seven selections with a view to enter them in the next HDC funded rootstock trial, namely PQ5-12, PQ5-13, PQ5-16, PQ5-18 (quince) and PQ34-3, PQ34-6, PQ35-2 (*Pyrus*). Additionally, as agreed at the EMRC management committee meeting in September 2012, the same accessions were sent to CIV (Italy) to initiate the establishment of mother plants. The only exception was PQ34-6 due to lack of growth. This selection could be provided in 2014.

2. Preliminary trials

2.1. Apple:

The most recent apple rootstock trial (RF185), established in March 2012, evaluates four selections from the M306 family ('AR86-1-20' x 'M.20') grafted with 'Gala' and includes 'M.9', 'M.116' and 'M.M.106' for reference. Trees were planted in two rows (5 m × 3 m) according to a randomised design (Fig. 2) with guards on 'M.9' at the ends and between blocks; the guards will also act as pollinators, having been worked with 'Fiesta' and 'Braeburn'. DNA testing was carried out prior to planting to ensure all selections and controls were true to type. All trees survived their first growing season in the field and no early signs of graft-incompatibility have been recorded.

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

Preliminary records, taken 11 months after planting, already show differences in vigour in these young trees (Table 10). In particular, significant differences were found for both girth and shoot length. For girth, 'M306-79' and 'M306-189' were found to be similar to 'M9' and significantly smaller than 'M306-6' and 'M306-20' which were both comparable to both 'MM106' and 'M116'. For shoot length, 'M306-189' produced the shortest shoots which placed it within the same category as 'M9', whilst the other selections had shoot lengths similar to 'M116. The other parameter measured, number of shoots per tree, was found to be very variable within genotypes and as such no significant difference between selections was identified.

Table 10. The effects of apple rootstocks on the growth of Gala apple trees in 2012 (Plot RF185). Trees planted March 2012. (*, ** and *** indicates rootstock effect significant at the 5, 1 and 0.1% level respectively, ns indicates no significant effect; significantly different groups have been denoted with letters a – c in superscript).

Rootstock	2012-13 data		
	Girth (cm)	Number of shoots per tree	Average shoot length (cm)
M306-6	4.4[b]	9.2	14.8[bc]
M306-20	4.4[b]	12.5	21.0[c]
M306-79	3.8[a]	8.0	11.8[ab]
M306-189	3.5[a]	4.2	5.8[a]
M.9	3.7[a]	6.0	8.8[ab]
M.M.106	4.6[b]	8.2	14.0[b]
M.116	4.4[b]	10.5	16.8[bc]
SED (18 d.f.)	0.2	2.7	3.14
Significance	***	ns	**
LSD p=0.05	0.5	5.7	6.6

2.1. Pear and quince:

The evaluation of two trials of rootstocks for pear planted in 2006 (plots DM177 and DM178) continued in 2012. Both trials include quince rootstock controls EMA and EMC, the latter from two different sources which continue to perform differently. Tables 11 and 13 summarise the results for plots DM177 (Pyrus) and DM178 (Quince), respectively, and Tables 12 and 14 give a summary of the statistical interpretation of these data. Overall 2012 was a poor year for fruit set with yields from both trials being very low. Consequently, analysis of yield on both plots failed to show any significant differences when comparing all the genotypes within each trial.

Table 11. The effects of Pyrus and Quince (QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2012. (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).

Rootstock	2012 data					Cumulative data (2007-2012)		
	Girth (cm)	Tree Volume (m^3)	Total Yield (kg/tree)	Class 1 fruit (kg/tree)		Total Yield (kg/tree)	Fruit >65mm (kg/tree)	Yield efficiency (kg/cm^2)
				>65mm	55-65mm			
PQ34-1	17.8	7.0	1.3	0.2	0.0	19.6	5.0	1.33
PQ34-2	13.0	5.6	2.8	0.8	0.2	9.0	1.4	1.03
PQ34-3	19.3	8.6	4.2	1.3	2.2	29.4	4.9	1.52
PQ34-4	11.0	2.8	0.3	0.2	0.0	3.2	0.3	0.42
PQ34-5	14.9	4.7	2.6	1.0	0.0	13.8	1.5	1.04
PQ34-6	16.4	4.5	0.0	0.0	0.0	21.7	2.0	1.28
PQ35-1	10.9	2.8	4.1	0.8	1.2	7.8	1.1	1.14
PQ35-2	13.6	3.4	0.1	0.0	0.0	14.8	1.6	1.23
PQ35-3	6.1	0.3	4.3	2.2	0.2	5.5	2.6	4.11
EMA	18.0	9.0	2.6	0.8	0.8	21.5	4.5	1.14
EMC ex Blackmoor	12.4	2.7	1.9	0.3	0.2	11.2	1.5	1.13
EMC ex Keepers	16.0	4.9	1.3	0.3	0.7	18.7	2.1	1.89
SED (38 d.f.)	1.83	2.42	4.23	1.32	1.75	6.0	2.4	0.48
Significance	***	***	ns	ns	ns	***	**	***
LSD p=0.05	3.71	4.90	8.56	2.68	3.55	12.1	4.9	0.97

Table 12. Summary of the interpretation of *Genstat* results for Pyrus rootstock trial in plot DM177. Statistically significant differences (at 5% level) between the selection and the controls are indicated: 'L' denotes a value lower than the control and 'H' a value higher than the control

Rootstock	2012 data															Cumulative data (2007-2012)								
	Girth			Tree Volume			Total Yield			>65mm Yield			55-65mm Yield			Total Yield			>65mm Yield			Yield efficiency		
	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K
PQ34-1	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ34-2	L	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*	*	*	*
PQ34-3	*	H	*	*	H	H	*	*	*	*	*	*	*	*	*	*	H	*	*	*	*	*	*	*
PQ34-4	L	*	L	L	*	*	*	*	*	*	*	*	*	*	*	L	*	L	*	*	*	*	*	L
PQ34-5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ34-6	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ35-1	L	*	L	L	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*	*	*	*
PQ35-2	*	*	*	L	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ35-3	L	*	L	L	*	*	*	*	*	*	*	*	*	*	*	L	*	L	*	*	*	H	H	H
QA	n/a	H	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*
QC-B	*	n/a	*	L	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*
QC-K	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a

QA=Quince A; QC-B=Quince C, Blackmoor Nurseries, QC-K=Quince C, Keepers Nursery.

Table 13. The effects of Quince (including QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2012. (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	2012 data					Cumulative data (2007-2012)		
	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)
PQ5-1	16.1	5.6	3.0	1.2	1.1	18.2	3.5	1.35
PQ5-2	17.6	5.6	1.1	0.4	0.1	23.5	2.7	1.25
PQ5-3	14.4	6.1	3.1	0.8	1.5	21	3.2	1.85
PQ5-6	19.8	9.2	1.1	0.1	0.4	28.1	2.3	1.25
PQ5-7	14.4	7.3	3.7	2.2	0	12.3	3.6	1.04
PQ5-8	17.7	8.2	0.1	0	0	22	4.2	1.26
PQ5-9	16.3	6.0	0.5	0.1	0.1	13.0	1.5	0.84
PQ5-10	16.1	6.0	2.2	1.3	0.3	13.2	3.0	0.88
PQ5-11	14.1	4.2	1.3	0.7	0.2	8.7	1.2	0.84
PQ5-12	13.1	2.6	0.1	0	0	10.7	2.2	1.17
PQ5-13	14.0	4.8	5.4	2.4	0.2	23.3	4.7	2.18
PQ5-16	19.7	10.2	0.3	0.1	0.1	24.9	4.0	1.14
PQ5-18	18.7	7.0	1.6	0.7	0.1	25.4	6.0	1.36
PQ5-19	13.0	3.6	0.5	0.3	0.1	11.4	1.3	1.22
PQ5-20	17.3	5.5	1.9	0.6	0.5	22.5	3.4	1.32
PQ5-21	14.9	3.5	0.6	0.5	0.2	16	0.9	1.21
PQ5-22	20.4	7.2	4.4	2.2	0.6	30.1	9.3	1.24
EMA	18.3	9.2	3.6	1.0	1.1	27.5	7.0	1.38
EMC ex Blackmoor	14.1	6.6	4.3	0.5	0.7	22.0	4.0	1.75
EMC ex Keepers	16.0	3.9	2.8	0.7	0.9	21.6	4.0	1.32
SED (48 d.f.)	2.3	2.7	2.8	0.9	1.1	6.7	2.2	0.33
Significance	***	**	ns	ns	ns	***	***	***
LSD p=0.05	4.5	5.5	5.6	1.9	2.2	13.4	4.3	0.66

Table 14. Summary of the interpretation of *Genstat* results for Pyrus rootstock trial in plot DM178. Statistically significant differences (at 5% level) between the selection and the controls are indicated: 'L' denotes a value lower than the control and 'H' a value higher than the control.

Rootstock	2012 data															Cumulative data (2007-2012)								
	Girth			Tree Volume			Total Yield			>65mm Yield			55-65mm Yield			Total Yield			>65mm Yield			Yield efficiency		
	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K	QA	QC-B	QC-K
PQ5-1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-6	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*
PQ5-7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*	*	L	*
PQ5-8	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	L	*	*	*	L	*
PQ5-10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*	*	L	*
PQ5-11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	L	*	*	*	L	*
PQ5-12	L	*	*	L	*	*	*	*	*	*	*	*	*	*	*	L	*	*	L	*	*	*	*	*
PQ5-13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	H	*	*
PQ5-16	*	H	*	*	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-18	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-19	L	*	*	L	*	*	*	*	*	*	*	*	*	*	*	L	*	*	L	*	*	*	*	*
PQ5-20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PQ5-21	*	*	*	L	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	*	*
PQ5-22	*	H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	H	H	*	*	*
QA	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*
QC-B	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*
QC-K	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a	*	*	n/a

QA=Quince A; QC-B=Quince C, Blackmoor Nurseries, QC-K=Quince C, Keepers Nursery.

In the Pyrus plot (DM177), PQ35-3 ((B13 x Old Home) x (B13 x Old Home)) appeared to be the most dwarfing rootstock but also the highest yield selection, resulting in significantly greater yield efficiency than any other selection or control in the trial. The percentage of fruit >65mm was also high, although not significantly different from the controls. PQ34-3 ((*P. communis* Ankara op) x (B13 x Old Home)) remains the most productive selection although its yield in 2012 was modest.

In the Quince plot (DM178), PQ5-3 and PG5-13 displayed the highest yield efficiency, with the latter selection producing the highest yield in the 2012 trial. Both selections also showed lower vigour than two of the controls.

3. Crossing programme for 2013

3.1. Apple:

The main aim of the apple programme is to introduce pest and disease resistance into the 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 are:

- **M.9** and **M.27:** dwarfing and very dwarfing respectively but susceptible to most pest and diseases
- **M.116** (M.M.106 x M.27): semi-vigorous (~ to M.M.106), 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 M.26)): very resistant to mildew, not very vigorous
- **AR295-6** (*Malus robusta* 5 x Ottawa 3): promising dwarfing selection, waa susceptible
- **Hibernal:** tetraploid, very resistant to mildew, easy rooting
- **Budagovsky 9** (M.8 x Krasny Shtandard): selected in Poland, dwarfing (~M.9), precocious, winder hardy, fairly fireblight resistant in the field, collar-rot resistant, moderate resistance to mildew and scab in the nursery
- **Geneva 11** (M.26 x *Malus robusta* 5): dwarfing (~M.9), very precocious, good yield efficiency, adequate rooting, low suckering, no burr-knots, fairly resistant to fireblight, moderately WAA resistant
- **Geneva 30** (M.26 x *Malus robusta* 5): dwarfing (~M.9), very precocious, good yield efficiency, adequate rooting, low suckering, no burr-knots, fairly resistant to fireblight, moderately WAA resistant
- **Geneva 202** (M.27 x *Malus robusta* 5): semi-dwarfing (~M.26, ~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**: selected in what is now Israel from the 1920s to 1940s, 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*.

3.2. 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 two controlled crosses will be carried out using the following potential parents:

- **P525-3:** dwarf pear scion
- **OHxF 87:** semi-dwarfing, precocious, promotes early spurring, slightly more dwarfing than OHxF 97
- **Pyrodwarf:** semi-vigorous, fire blight resistant, precocious (yet to flower at EMR)
- **Pyronia:** Pear x quince hybrids; compact habit. Flowered