Project number: TF 182

Project leader: Ms Felicidad Fernández, East Malling Research

Key staff: Mr Adam Whitehouse, Ms Marzena Lipska

Location of project: East Malling Research

Project coordinator: Mr Nigel Kitney

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 ....31/08/2014......................

Report authorised by:

Prof. Xiangming Xu
Programme Leader
East Malling Research

Signature ....................................................... Date ....4/09/2014............
Grower Summary

Headline

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

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.

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

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

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

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

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

Crossing programme

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

Seedling populations and

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

Selection and propagation

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

Pest and disease screening

- Seven apple selections were screened for fire-blight resistance in 2013, with AR295-6 performing better than all the other selections with less than 50% necrosis
- Woolly apple aphid screen was carried out on 12 apple selections, but colonies did not thrive leading to inconclusive results
Preliminary results

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

Financial benefits

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

Action points for growers

None at this point.
-
East Malling Rootstock Club annual report 2013-14

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 Institution).

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 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 is not unusual for new rootstock to take 30-35 years. 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 to identify a range of apple, pear and quince rootstocks with desirable size control, precocity and productivity, with resistance to diseases and pests where applicable.

**Aims and objectives**

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

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

**General Methods**

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

**Crossing**

Parental genotypes that carry one or more phenotypic traits of interest are selected and a crossing programme is designed aiming to combine those desirable characteristic into the resulting seedlings. Controlled crosses are carried out in spring: first, the anthers of the intended male parent are extracted from unopened blossoms to avoid cross contamination and placed in Petri dishes until the 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 for until the following January.

**Raising seedling populations**

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

Field evaluation of rootstock seedlings

In the first winter, 1-year-old bare-rooted plants of 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 on each seedling with regards to vigour, production of suckers as well as pest and disease incidence in those suckers. As the common scion comes into fruit, differences attributable to the rootstocks such as fruit size and crop load are also recorded for two 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 can be discarded (e.g. severe mildew infection or waa infestation).

Hardwood cuttings (ideally ~ 30 cm in length) are taken of these selections at the beginning of December and dipped in 0.5% (Indole-3-butyric 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°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; 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 cm² of cross section) are calculated. Records are taken on 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 M9 rootstocks, from there four to eight trees of each genotype are then sent to the Julius Kuehn-Institute (JKI) in Germany to be tested by Dr Klaus Richter’s group. The trees are challenged with a mix of Erwinia amylovora after every growth event (5-8 times per season) and the percentage of necrotic shoot length is recorded for each individual plant as well as for M9 susceptible controls.

Woolly apple aphid (WAA)

Colonies of Eriosoma lanigerum (WAA) collected from the field at EMR are used to challenge rooted cuttings in the glasshouse. Aphids are added to each tree 2-3 time 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

Spring was rather late in 2013. Following some cold snaps in the late winter, trees did not start to flower until mid-late April and crossing in apples carried on into early May. Generally, fruit set was better than in 2011 and 2012 although seed numbers varied greatly depending on the cross. Details of the cross, including the number of fruit collected and number of seed extracted are shown in Table 1.1 (apple) and 1.2 (pear). Pear seed will be stored for sowing in 2015 whilst apple seeds were all sown in Jan 2014.

Table 1.1. Summary of result from apple crossing 2013

<table>
<thead>
<tr>
<th>Female x Male</th>
<th>Flowers pollinated</th>
<th>Fruit set</th>
<th>Fruits collected</th>
<th>Aborted seed</th>
<th>Seeds extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>A469-4 x MH.10.1</td>
<td>14</td>
<td>8</td>
<td>12</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>A469-4 x MH.12.3</td>
<td>2</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bud 9 x Evereste</td>
<td>211</td>
<td>21</td>
<td>24</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Evereste x M.9</td>
<td>194</td>
<td>109</td>
<td>118</td>
<td>25</td>
<td>345</td>
</tr>
<tr>
<td>Evereste x Geneva 30</td>
<td>736</td>
<td>18</td>
<td>5</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Geneva 11 x AR295-6</td>
<td>42</td>
<td>23</td>
<td>21</td>
<td>13</td>
<td>67</td>
</tr>
<tr>
<td>Geneva 30 x M.27</td>
<td>172</td>
<td>87</td>
<td>28</td>
<td>75</td>
<td>29</td>
</tr>
<tr>
<td>Geneva 30 x AR295-6</td>
<td>74</td>
<td>32</td>
<td>41</td>
<td>12</td>
<td>171</td>
</tr>
<tr>
<td>M.27 x Geneva 11</td>
<td>34</td>
<td>5</td>
<td>20</td>
<td>5</td>
<td>47</td>
</tr>
<tr>
<td>M.9-A x Evereste</td>
<td>217</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>M.9EMLA x Sally</td>
<td>168</td>
<td>17</td>
<td>17</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>M.M.106 x Geneva 30</td>
<td>72</td>
<td>13</td>
<td>9</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>Torstein x M.27</td>
<td>104</td>
<td>7</td>
<td>46</td>
<td>54</td>
<td>242</td>
</tr>
<tr>
<td>Torstein x M.9</td>
<td>118</td>
<td>5</td>
<td>35</td>
<td>50</td>
<td>133</td>
</tr>
<tr>
<td>Geneva 30 x AR295-6</td>
<td>74</td>
<td>42</td>
<td>41</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hibernal x MH 10.1</td>
<td>112</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Hibernal x MH 16.7</td>
<td>52</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hibernal x MH 12.3</td>
<td>52</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hibernal x MH14.5</td>
<td>90</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1.2. Summary of result from pear crossing 2013

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

*Diploid
In total, 1,182 apple (29 trays) seeds were sown in January 2014 and stratified at 2°C for 12 weeks. In April 2014 they were transferred to a heated glasshouse under natural lighting. Germination was variable (Table 1.3) but generally good, 85% overall, (Figure 1). Seedlings will be potted up in May 2014 weaned and planted in the field in June-July 2014.

Table 1.3. Apple seedling germination in 2014

<table>
<thead>
<tr>
<th>Family</th>
<th>Cross</th>
<th>Year of crossing</th>
<th>Seeds Sown</th>
<th>Trays</th>
<th>Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>M573</td>
<td>Bud.9 x Everest</td>
<td>2013</td>
<td>12</td>
<td>1</td>
<td>50%</td>
</tr>
<tr>
<td>M574</td>
<td>Everest x M.9</td>
<td>2013</td>
<td>345</td>
<td>7</td>
<td>86%</td>
</tr>
<tr>
<td>M575</td>
<td>M.9A x Everest</td>
<td>2013</td>
<td>14</td>
<td>1</td>
<td>45%</td>
</tr>
<tr>
<td>M576</td>
<td>A469-4 x MH.10.1</td>
<td>2013</td>
<td>40</td>
<td>1</td>
<td>65%</td>
</tr>
<tr>
<td>M577</td>
<td>Everest x Geneva 30</td>
<td>2013</td>
<td>12</td>
<td>1</td>
<td>45%</td>
</tr>
<tr>
<td>M578</td>
<td>Geneva 11 x AR295-6</td>
<td>2013</td>
<td>67</td>
<td>2</td>
<td>96%</td>
</tr>
<tr>
<td>M579</td>
<td>Geneva 30 x M.27</td>
<td>2013</td>
<td>29</td>
<td>1</td>
<td>49%</td>
</tr>
<tr>
<td>M580</td>
<td>Geneva 30 x AR295-6</td>
<td>2013</td>
<td>171</td>
<td>4</td>
<td>85%</td>
</tr>
<tr>
<td>M581</td>
<td>M.27 x Geneva 11</td>
<td>2013</td>
<td>47</td>
<td>1</td>
<td>88%</td>
</tr>
<tr>
<td>M582</td>
<td>M.M.106 x Geneva 30</td>
<td>2013</td>
<td>39</td>
<td>1</td>
<td>91%</td>
</tr>
<tr>
<td>M583</td>
<td>Torstein x M.27</td>
<td>2013</td>
<td>242</td>
<td>5</td>
<td>86%</td>
</tr>
<tr>
<td>M584</td>
<td>Torstein x M.9</td>
<td>2013</td>
<td>133</td>
<td>3</td>
<td>95%</td>
</tr>
<tr>
<td>M585</td>
<td>M.9EMLA x Sally</td>
<td>2013</td>
<td>31</td>
<td>1</td>
<td>35%</td>
</tr>
</tbody>
</table>

Figure 1. 2014 apple rootstock seedlings in the glasshouse at EMR
1.1.2. Establishment and budding

A total of 211 new apple seedlings from six progenies (Table 2.1) were planted in August 2013 in double rows (same spacing as in 2012) in SP246. Similarly, 556 new pear seedlings from four different progenies were also planted in August 2013 (Table 2.2) in SP247. Of particular interest is family PRP52 not only because of the large number of seedlings it comprises but because it combines dwarf and dwarfing genes, making it ideal for genetic studies. Thus, leaf samples of all seedlings were collected for DNA extraction and a vigour record was taken classing seedlings as dwarf or normal. Additionally, prior to budding in 2014, we will also record internode length in the whole population. Apple families planted out in summer 2012 (Table 3) were budded in August 2013.

Table 2.1. Apple rootstock seedling population planted in Aug 2013 (Plot SP246)

<table>
<thead>
<tr>
<th>Family</th>
<th>Cross</th>
<th>Year of crossing</th>
<th>Germination</th>
<th>Planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>M566</td>
<td>Budagovsky 9 x Evereste</td>
<td>2012</td>
<td>2013</td>
<td>17</td>
</tr>
<tr>
<td>M567</td>
<td>M.27 x Geneva 11</td>
<td>2012</td>
<td>2013</td>
<td>11</td>
</tr>
<tr>
<td>M568</td>
<td>Torstein x M.27</td>
<td>2012</td>
<td>2013</td>
<td>4</td>
</tr>
<tr>
<td>M569</td>
<td>Torstein x M.9</td>
<td>2012</td>
<td>2013</td>
<td>11</td>
</tr>
<tr>
<td>M570</td>
<td>Geneva 202 o.p.</td>
<td>2012</td>
<td>2013</td>
<td>88</td>
</tr>
</tbody>
</table>

Table 2.2. Pear rootstock seedling population planted in Aug 2013 (Plot SP247)

<table>
<thead>
<tr>
<th>Family</th>
<th>Cross</th>
<th>Year(s) of crossing</th>
<th>Planted</th>
<th>Seedlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRP49a</td>
<td>PB11-30 OHxF333</td>
<td>2010</td>
<td>2013</td>
<td>69</td>
</tr>
<tr>
<td>PRP50a</td>
<td>OHxF87 x BP1</td>
<td>2010</td>
<td>2013</td>
<td>132</td>
</tr>
<tr>
<td>PRP51</td>
<td>OHFx87 x P525-3</td>
<td>2011&amp;12</td>
<td>2013</td>
<td>4</td>
</tr>
<tr>
<td>PRP52</td>
<td>B13 x P525-3</td>
<td>2011&amp;12</td>
<td>2013</td>
<td>351</td>
</tr>
</tbody>
</table>

Table 3. Rootstock progenies budded in August 2013 (Plot SP241)

<table>
<thead>
<tr>
<th>Family</th>
<th>Cross</th>
<th>Year of crossing</th>
<th>Planted in 2012</th>
<th>Budded with</th>
</tr>
</thead>
<tbody>
<tr>
<td>M555a</td>
<td>Geneva 30 o.p.</td>
<td>2009</td>
<td>123</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M556a</td>
<td>Ottawa 3 o.p.</td>
<td>2009</td>
<td>85</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M559a</td>
<td>Bud.9 x M.9</td>
<td>2010</td>
<td>56</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M560a</td>
<td>AR86-1-20 x Geneva 11</td>
<td>2010</td>
<td>183</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M561</td>
<td>M.27 x Geneva 30</td>
<td>2010</td>
<td>6</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M562a</td>
<td>M.M.106 x Geneva 202</td>
<td>2010</td>
<td>181</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M563a</td>
<td>M.M.106 x Bud. 9</td>
<td>2010</td>
<td>67</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M564</td>
<td>Geneva 202 x M.27</td>
<td>2011</td>
<td>10</td>
<td>SA544-28</td>
</tr>
<tr>
<td>M565</td>
<td>Bud.9 x M.116</td>
<td>2011</td>
<td>8</td>
<td>SA544-28</td>
</tr>
</tbody>
</table>
1.2. Seedling populations in the pipeline and selection

1.2.1. Apple

Records on vigour, crop and presence of suckers continued in the reporting year for seedlings in SC194 [M550 (AR86-1-20 x M.9), M551 (M.16 x M.9) and M552 (White Angel x M.9)]. These families were all planted in 2007 and worked with SA544-28 a year later; selections will be made in these populations after final evaluation in 2014. Records on height and trunk diameter above the graft union were also taken on families planted in 2010 in plot SC198 [M553 (AR86-1-20 x Geneva 202), M554 (M.M.106 x Geneva 30), M555 (Geneva 30 o.p.) and M556 (Ottawa 3 o.p.)]. Three tentative selections (Table 4.1) were made from family M580 (unknown pedigree) in SC190. However, relatively good yields in 2013 require confirmation so they will be added to the 2014/15 propagation list once crop load is recorded in 2014.

Table 4.1. Tentative apple selections made in summer 2013

<table>
<thead>
<tr>
<th>Plot</th>
<th>Selection</th>
<th>Vigour</th>
<th>Crop load*</th>
<th>Suckering</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC190</td>
<td>M580-4</td>
<td>mw</td>
<td>ml</td>
<td>-</td>
</tr>
<tr>
<td>SC190</td>
<td>M580-16</td>
<td>w</td>
<td>ml</td>
<td>+</td>
</tr>
<tr>
<td>SC190</td>
<td>M580-32</td>
<td>w</td>
<td>m</td>
<td>+</td>
</tr>
</tbody>
</table>

1.2.2. Pear

In this reporting year, the evaluation of the pear families planted in 2006 (SC193) was completed. Records were taken of the vigour, incidence of suckering and crop load for families PQ42 (OHxF 51 x P. amygdaliformus), PQ43 (OHxF 69 x P. amygdaliformus) and PQ44 (OHxF 333 x P. betulifolia) in late September 2013. In all, 13 selections were made; six from PQ42, four from PQ43 and three from PQ44 (Table 4.2).

Table 4.2. A summary of the characteristics for each of these selections is shown below in table

<table>
<thead>
<tr>
<th>Plot</th>
<th>Selection</th>
<th>Vigour</th>
<th>Fruiting (y/n)</th>
<th>Suckering</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC193</td>
<td>PQ42-11</td>
<td>m</td>
<td>y</td>
<td>+</td>
</tr>
<tr>
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<td>PQ42-23</td>
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<td>n</td>
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<tr>
<td>SC193</td>
<td>PQ42-33</td>
<td>m</td>
<td>m</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ42-47</td>
<td>mw</td>
<td>n</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ42-50</td>
<td>mw</td>
<td>m</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ42-138</td>
<td>w</td>
<td>n</td>
<td>++</td>
</tr>
<tr>
<td>SC193</td>
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<tr>
<td>SC193</td>
<td>PQ43-42</td>
<td>m</td>
<td>m</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ43-50</td>
<td>m</td>
<td>m</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ43-57</td>
<td>v</td>
<td>n</td>
<td>0</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ44-10</td>
<td>mw</td>
<td>n</td>
<td>+</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ44-11</td>
<td>w</td>
<td>n</td>
<td>+</td>
</tr>
<tr>
<td>SC193</td>
<td>PQ44-26</td>
<td>mw</td>
<td>n</td>
<td>++</td>
</tr>
</tbody>
</table>
1.3. Propagation

Pear selections made in 2013 (Table 4.2) were cut down below the graft union in December 2013 fitted with plastic rings to retain rooting substrate around the collar (Figure 2). This has been shown to encourage shoot growth from the original root system and collar. It also protects the growing shoots as well as the labels from mechanical damage during the season.

![Figure 2. Improved earthing method using plastic rings to keep rooting substrate around the collar area during the growing season.](image)

Propagation continued in winter 2013-14 of all selections currently in the pipeline and a summary of the numbers of cuttings taken from selections at different stages in December 2013 is shown in Tables 5.1 (pear) and 5.2 (apple). This includes the first round of cuttings from families selected in 2012. Thanks to the use of collars in 2012 (Figure 2), propagation of selections in the field looks very promising with a higher number of more vigorous suckers produced than in previous years some of which already showed nicely-developed roots at the time of lifting.

Additionally, the re-propagation of EM apple germplasm collection started in February 2013 continued in 2014 with grafting completed by the end of February. Land preparation for the new apple genebank has already started and we expect to plant between Nov 2014 and spring 2015. A plot has also been allocated and ground is being prepared for the mother plants of recent selections to be planted as hedges in 2014.

**Table 5.1.** Cuttings taken from pear selections in December 2013

<table>
<thead>
<tr>
<th>Plot</th>
<th>Selection</th>
<th>Selection year</th>
<th>Number of cuttings</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Field</td>
<td>Glasshouse</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hardwood  Rooted</td>
<td>Hardwood</td>
<td>taken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC185</td>
<td>PQ41-9</td>
<td>2012</td>
<td>4  6</td>
<td>-</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC185</td>
<td>PQ41-26</td>
<td>2012</td>
<td>1  1</td>
<td>-</td>
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<td></td>
</tr>
<tr>
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<td>PQ41-52</td>
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</tr>
<tr>
<td>SC185</td>
<td>PQ41-57</td>
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<td>-</td>
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</tr>
<tr>
<td>SC185</td>
<td>PQ41-60</td>
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<td>-</td>
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</tr>
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<td>-</td>
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Table 5.2. Cuttings taken from apple selections in December 2013

<table>
<thead>
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<th>Plot</th>
<th>Selection</th>
<th>Selection year</th>
<th>Number of cuttings</th>
<th></th>
<th>Field</th>
<th>Glasshouse</th>
<th>Total taken</th>
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<tr>
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<td>Rooted</td>
<td>Hardwood</td>
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</table>
1.4. Screening advanced selections for pest and disease

1.4.1. Fire-blight (FB)

Graft-wood of seven EMR advanced selections (Table 6) was sent to LUBERA’s nursery in Switzerland for grafting to M9 rootstocks. Between one and 10 trees of each genotype were then sent to the Julius Kuehn-Institute (JKI) in Germany to be tested for resistance to FB by Dr Klaus Richter’s group. Following repeated inoculation with *Erwinia amylovora* isolates ‘Ea797’, ‘Ea839’ and ‘Ea951’. The initial inoculation took place on the 5th of June and it was then repeated weekly for 6 weeks. The percentage of necrotic shoot length was recorded for each individual plant as well as for M9 and Supporter 4 susceptible controls at the end of July 2013 (Table 6). Necrosis severity varied considerably within genotypes but less so than in 2012. Based on 2012 results alone, we would have concluded that all selections tested were susceptible to very susceptible. Taking this year’s results also into consideration we can also infer that susceptibility levels for AR839-9 and AR835-11, and possibly AR837-19, are less extreme that for other selections and comparable to M.9 and S.4.

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

Table 6. Summary of fire blight (FB) resistance screening for nine EMR rootstock genotypes following repeated inoculation with *Erwinia amylovora* isolates ‘Ea782’, ‘Ea797’ and ‘Ea914’ in 2012 and ‘Ea797’, ‘Ea839’ and ‘Ea951’ in 2013

<table>
<thead>
<tr>
<th>Genotype</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of necrosis</td>
<td>% of necrosis</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>AR10-2-5</td>
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<td>77.9</td>
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<td>40.8</td>
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<td>M.9 T337</td>
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* all except one < 50%
1.4.2. Woolly apple aphid (WAA)

Unusually high temperature in July and early August put trees under unusual stress increasing the incidence of red spider mite to levels that could not be controlled with predatory mites. Whilst aphid colonies did better than in the previous summer, they did not thrive as we would have liked partly due to parasites emerging in the population. Results for 2013 and our interpretation of them and those for 2012 are presented in Table 7.

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

Table 7. Woolly apple aphid (WAA) inoculation results for 2013 and summary of indexing for 2012 and 2013. Controls underlined

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR10-3-9</td>
<td>5</td>
<td>3 2 0 0</td>
<td>1 3 1 0</td>
<td>Sus?</td>
<td>Sus?</td>
</tr>
<tr>
<td>AR69-7</td>
<td>2</td>
<td>2 0 0 0</td>
<td>2 0 0 0</td>
<td>Res?</td>
<td>n.t.</td>
</tr>
<tr>
<td>AR295-6</td>
<td>1</td>
<td>1 0 0 0</td>
<td>0 1 0 0</td>
<td>Inconclusive (Sus)</td>
<td>Sus</td>
</tr>
<tr>
<td>AR628-2</td>
<td>6</td>
<td>4 0 2 0</td>
<td>5 0 0 1</td>
<td>Sus?</td>
<td>n.t.</td>
</tr>
<tr>
<td>AR682-6</td>
<td>5</td>
<td>3 0 2 0</td>
<td>3 2 0 0</td>
<td>Inconclusive</td>
<td>n.t.</td>
</tr>
<tr>
<td>AR801-11</td>
<td>2</td>
<td>1 1 0 0</td>
<td>1 1 0 0</td>
<td>Inconclusive</td>
<td>Sus?</td>
</tr>
<tr>
<td>AR809-3</td>
<td>4</td>
<td>1 0 3 0</td>
<td>2 1 1 0</td>
<td>Inconclusive</td>
<td>n.t.</td>
</tr>
<tr>
<td>AR835-11</td>
<td>2</td>
<td>0 0 2 0</td>
<td>1 0 0 1</td>
<td>Inconclusive</td>
<td>Sus?</td>
</tr>
<tr>
<td>B24</td>
<td>3</td>
<td>2 1 0 0</td>
<td>3 0 0 0</td>
<td>Res</td>
<td>Res?</td>
</tr>
<tr>
<td>R104</td>
<td>1</td>
<td>0 1 0 0</td>
<td>0 1 0 0</td>
<td>Inconclusive</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>M116</td>
<td>6</td>
<td>0 1 0 0</td>
<td>4 2 0 0</td>
<td>Inclusive (Res)</td>
<td>Res</td>
</tr>
<tr>
<td>M27</td>
<td>2</td>
<td>0 0 2 0</td>
<td>0 2 0 0</td>
<td>Inclusive (Sus)</td>
<td>Sus</td>
</tr>
<tr>
<td>M306-6</td>
<td>4</td>
<td>3 1 0 0</td>
<td>3 0 1 0</td>
<td>Inconclusive</td>
<td>n.t.</td>
</tr>
<tr>
<td>M306-20</td>
<td>4</td>
<td>3 1 0 0</td>
<td>3 0 1 0</td>
<td>Inconclusive</td>
<td>n.t.</td>
</tr>
<tr>
<td>M306-79</td>
<td>3</td>
<td>3 0 0 0</td>
<td>1 1 0 1</td>
<td>Sus?</td>
<td>n.t.</td>
</tr>
<tr>
<td>M306-189</td>
<td>2</td>
<td>2 0 0 0</td>
<td>0 1 1 0</td>
<td>Inconclusive</td>
<td>n.t.</td>
</tr>
</tbody>
</table>

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

Screening for resistance to WAA and FB in the advanced selections is an on-going effort that will continue in 2014. Table 8 summarises results so far an outlines work plan for 2014. Additionally, selections from families M432, M482, M508, M546, M547 and M549 will be included in the WAA screening as soon as a sufficient number of rooted cuttings become available.
Table 8. Advanced selections undergoing pest and disease screening and plans for 2014

<table>
<thead>
<tr>
<th>Selection number</th>
<th>Parentage</th>
<th>Woolly apple aphid</th>
<th>Fire Blight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Response³</td>
<td>EMR⁴</td>
</tr>
<tr>
<td>AR10-2-5</td>
<td>M.M.106</td>
<td>M.27</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR10-3-9</td>
<td>M.M.106</td>
<td>M.27</td>
<td>Susceptible?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR295-6</td>
<td>Robusta 5</td>
<td>Ottawa 3</td>
<td>Susceptible</td>
</tr>
<tr>
<td>B24</td>
<td>AR10-2-5</td>
<td>AR86-1-22</td>
<td>Resistant?</td>
</tr>
<tr>
<td>R80</td>
<td>AR134-31</td>
<td>AR86-1-22</td>
<td>?</td>
</tr>
<tr>
<td>R104</td>
<td>AR134-31</td>
<td>AR86-1-22</td>
<td>?</td>
</tr>
<tr>
<td>AR628-2</td>
<td>Ottawa 3</td>
<td>M.M.106</td>
<td>?</td>
</tr>
<tr>
<td>AR680-2</td>
<td>M.26</td>
<td>M.7</td>
<td>Susceptible?</td>
</tr>
<tr>
<td>AR682-6</td>
<td>M.26</td>
<td>M.I.793</td>
<td>?</td>
</tr>
<tr>
<td>AR801-11</td>
<td>M.26</td>
<td>M.1</td>
<td>Susceptible</td>
</tr>
<tr>
<td>AR835-11</td>
<td>M.I.793</td>
<td>M.9a</td>
<td>Susceptible?</td>
</tr>
<tr>
<td>AR837-19</td>
<td>M.3</td>
<td>M.1</td>
<td>?</td>
</tr>
<tr>
<td>AR852-3</td>
<td>AR362-16</td>
<td>op</td>
<td>Susceptible?</td>
</tr>
</tbody>
</table>

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

1.4.3. Other disease screening

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

1.5. Distribution of propagation material for further trialling

1.5.1. Apple

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

1.5.2. Pear/Quince

Based on the preliminary result from the pear trials, seven selections, namely PQ5-12, PQ5-13, PQ5-16, PQ5-18 (quince) and PQ34-3, PQ34-6, PQ35-2 (*Pyrus*) were selected in 2012 for propagation with a view to enter them in the next HDC funded rootstock trial. Take was poor in 2012/13 and they were all collected again in Jan 2014 for rooting. Additionally, the EMRC management committee meeting in September 2013 agreed for the same accessions
were sent to CIV (Italy) to initiate the establishment of mother plants. Wood of all but PQ34-6 was provided in 2013 and 2014. Following 2013 trial results, we recommend this list to be slightly amended (see section 2.2.).

Additionally, DNA was obtained from the mother plants of all PQ34 and PQ35 pear selections and compared with a representative tree in DM177. All selections of interest were found to be true-to-type in the trial. We have still to finalise a suitable fingerprinting set for quince but work in on-going.

2. Preliminary trials

2.1. Apple (RF185)

This trial, planted in March 2012, compares four selections from the M306 family (‘AR86-1-20’ x ‘M.20’) grafted with ‘Gala’ to three control rootstocks: ‘M.9’, ‘M.116’ and ‘M.M.106’. Trees were planted in two rows (5 m x 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. No clear signs of rootstock-scion incompatibility were noted in the reporting period.

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

Fruit was harvested on this trial for the first time on 4th October 2013 with winter records completed in January 2014. Data from this trial is shown in Tables 9 (a) and (b).

In terms of rootstock effect on tree growth, we have seen significant differences in girth. As in the previous year, M306-6 and M306-20 showed similar trunks to that of M.M.106 and M.116 and M306-79 continue to be in the same group as M.9 (in girth as well as yield efficiency) whilst M306-189 was found to have a narrower girth than all the other selections and standards, in fact showing almost no expansion since the 2012 records were taken. It also produced trees with very low tree volume although this result was not found statistically significant due to high variation between replicates.

There was a light crop on these trees with the only statistical significance relating to the
higher number of fruit and yield of class 1 fruit (> 65 mm) produced from the control ‘M.9’ stock. However, if looking at trends, M306-79 appears to be as productive as ‘M.9’ although with smaller fruit size, similar to ‘M.M.106’ in this trial but it is too early to draw any firm conclusions from these findings.

Table 9 (a). The effects of apple rootstocks on the growth of Gala apple trees in 2013 (RF185, planted March 2012).

| Rootstock | 2013 data | | | |
|-----------|-----------|-----------|-----------|
|           | Girth (cm) | Tree volume (m³) | Yield efficiency (kg/cm²) |
| M306-6    | 5.6c       | 0.78       | 0.45ab     |
| M306-20   | 5.8c       | 0.75       | 0.10a      |
| M306-79   | 4.4b       | 0.58       | 0.78b      |
| M306-189  | 3.5a       | 0.25       | 0.48ab     |
| M.9       | 4.4b       | 0.45       | 0.72b      |
| M.M.106   | 5.4c       | 0.55       | 0.40a      |
| M.116     | 5.5c       | 0.50       | 0.18a      |
| SED (18 d.f.) | 0.32 | 0.19 | 0.18 |
| Significance | *** | ns | * |
| LSD p=0.05 | 0.67 | 0.39 | 0.37 |

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

Table 9 (b). The effects of apple rootstocks on the yield of Gala apple trees in 2013 (RF185, planted March 2012).

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Mean yield per tree (kg)</th>
<th>Mean number of fruit per tree</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[≥65mm] &lt; 65mm Total</td>
<td>≥65mm &lt; 65mm Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M306-6</td>
<td>0.1a 0.81 0.91 0.75a</td>
<td>8.8 9.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M306-20</td>
<td>0 0.22 0.22 0a</td>
<td>3.0 3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M306-79</td>
<td>0.18ab 1.06 1.23 1.5ab</td>
<td>11.8 13.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M306-189</td>
<td>0.06a 0.37 0.43 0.5a</td>
<td>6.8 7.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.9</td>
<td>0.44b 0.80 1.24 3.25b</td>
<td>8.8 12.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.M.106</td>
<td>0 0.90 0.90 0</td>
<td>13.5 13.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.116</td>
<td>0 0.39 0.39 0</td>
<td>4.0 4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SED (18 d.f.)</td>
<td>0.13</td>
<td>0.32</td>
<td>0.38</td>
<td>0.91</td>
<td>3.88</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>ns</td>
</tr>
<tr>
<td>LSD p=0.05</td>
<td>0.26</td>
<td>0.68</td>
<td>0.79</td>
<td>1.9</td>
<td>8.15</td>
</tr>
</tbody>
</table>

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

2.1. Pear and quince trial (DM177 and DM178)

The evaluation of two trials of rootstocks for pear planted in 2006 (plots DM177 and DM178) continued in 2013. DM177 and DM178 were harvested on the 2nd and 3rd of October 2013, respectively. Both trials include quince rootstock controls ‘EMA’ and ‘EMC’, the later from two different sources which continue to perform differently. Tables 10.1 and 11.1 summarise the results for plots DM177 (Pyrus) and DM178 (Quince), respectively. Yield was moderate at best. Further, most fruit was very elongated falling below the 55 mm ‘grade out’ and limiting discrimination on those grounds. Tables 10.2 and 11.2 illustrate fluctuation of cropping over the duration of the trial.
Table 10.1. The effects of Pyrus and Quince (QA and QC) rootstocks on the growth and cropping of
Conference pear trees in 2013. (DM177, planted March 2006). Selections discussed in the main text
are highlighted and those already in propagation are underlined.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>2013 data</th>
<th>Cumulative data (2007-2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girth (cm)</td>
<td>Tree Volume (m³)</td>
</tr>
<tr>
<td>PQ34-1</td>
<td>21.3</td>
<td>16.4</td>
</tr>
<tr>
<td>PQ34-2</td>
<td>15.2</td>
<td>8.5</td>
</tr>
<tr>
<td>PQ34-3</td>
<td>22.6</td>
<td>16.1</td>
</tr>
<tr>
<td>PQ34-4</td>
<td>11.7</td>
<td>3.0</td>
</tr>
<tr>
<td>PQ34-5</td>
<td>16.4</td>
<td>9.2</td>
</tr>
<tr>
<td>PQ34-6</td>
<td>18.1</td>
<td>10.6</td>
</tr>
<tr>
<td>PQ35-1</td>
<td>12.3</td>
<td>4.4</td>
</tr>
<tr>
<td>PQ35-2</td>
<td>14.1</td>
<td>3.4</td>
</tr>
<tr>
<td>PQ35-3</td>
<td>8.2</td>
<td>1.5</td>
</tr>
<tr>
<td>EMA</td>
<td>20.0</td>
<td>16.6</td>
</tr>
<tr>
<td>EMC ex Blackmoor</td>
<td>13.7</td>
<td>4.3</td>
</tr>
<tr>
<td>EMC ex Keepers</td>
<td>17.4</td>
<td>10.1</td>
</tr>
<tr>
<td>SED (38 d.f.)</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Significance</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>LSD p=0.05</td>
<td>4.0</td>
<td>6.1</td>
</tr>
</tbody>
</table>

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

Table 10.2. The yield pattern of Pyrus and Quince (QA and QC) rootstocks between 2010-13. (Plot
DM177). Trees planted March 2006. (*, ** and *** indicates rootstock effect significant at the 5, 1 and
0.1% level respectively, ns indicates no significant effect). Selections discussed in the main text are
highlighted and those already in propagation are underlined.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Total Yield (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQ34-1</td>
<td>3.6</td>
</tr>
<tr>
<td>PQ34-2</td>
<td>1.0</td>
</tr>
<tr>
<td>PQ34-3</td>
<td>3.0</td>
</tr>
<tr>
<td>PQ34-4</td>
<td>0.5</td>
</tr>
<tr>
<td>PQ34-5</td>
<td>0.3</td>
</tr>
<tr>
<td>PQ34-6</td>
<td>4.5</td>
</tr>
<tr>
<td>PQ35-1</td>
<td>0.4</td>
</tr>
<tr>
<td>PQ35-2</td>
<td>1.2</td>
</tr>
<tr>
<td>PQ35-3</td>
<td>0.0</td>
</tr>
<tr>
<td>EMA</td>
<td>1.9</td>
</tr>
<tr>
<td>EMC ex Blackmoor</td>
<td>0.4</td>
</tr>
<tr>
<td>EMC ex Keepers</td>
<td>2.5</td>
</tr>
<tr>
<td>SED (38 d.f.)</td>
<td>1.3</td>
</tr>
<tr>
<td>Significance</td>
<td>**</td>
</tr>
<tr>
<td>LSD p=0.05</td>
<td>2.6</td>
</tr>
</tbody>
</table>

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

Of the Pyrus rootstocks in DM177, PQ34-3 and PQ34-6 continued to perform comparably to
EMA (already in the propagation pipeline for further trials) as did PQ34-1. In fact, PQ34-1 and
PQ34-3 are no significantly different in vigour to it and PQ34-6 is only slightly more
dwarfing. Comparing the cumulative yield data, they are all similar to EMA, with PQ34-3
having almost identical yield & yield efficiency. PQ34-1 has slightly lower total yield, but not
significantly so. Additionally, they are all more precocious than EMC, judging by the 2010
harvest, and with the exception of the atrocious season of 2012 they have all shown performed consistently well.

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

**Table 11.1.** The effects of Quince (including QA and QC) rootstocks on the growth and cropping of Conference pear trees in 2013 (DM178, planted March 2006). Selections discussed in the main text are highlighted and those already in propagation are underlined.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>2013 data</th>
<th>Cumulative data (2007-2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girth (cm)</td>
<td>Tree Volume (m³)</td>
</tr>
<tr>
<td>PQS-1</td>
<td>17.8</td>
<td>8.9</td>
</tr>
<tr>
<td>PQS-2</td>
<td>19.1</td>
<td>7.6</td>
</tr>
<tr>
<td>PQS-3</td>
<td>15.7</td>
<td>6.9</td>
</tr>
<tr>
<td>PQS-6</td>
<td>21.4</td>
<td>17.4</td>
</tr>
<tr>
<td>PQS-7</td>
<td>15.7</td>
<td>10.2</td>
</tr>
<tr>
<td>PQS-8</td>
<td>19.3</td>
<td>11.5</td>
</tr>
<tr>
<td>PQS-9</td>
<td>17.6</td>
<td>8.7</td>
</tr>
<tr>
<td>PQS-10</td>
<td>17.7</td>
<td>11.0</td>
</tr>
<tr>
<td>PQS-11</td>
<td>16.1</td>
<td>8.4</td>
</tr>
<tr>
<td>PQS-12</td>
<td>14.3</td>
<td>4.2</td>
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<tr>
<td>PQS-13</td>
<td>16.0</td>
<td>8.6</td>
</tr>
<tr>
<td>PQS-16</td>
<td>21.6</td>
<td>21.5</td>
</tr>
<tr>
<td>PQS-18</td>
<td>20.6</td>
<td>14.1</td>
</tr>
<tr>
<td>PQS-19</td>
<td>14.1</td>
<td>5.1</td>
</tr>
<tr>
<td>PQS-20</td>
<td>19.0</td>
<td>9.0</td>
</tr>
<tr>
<td>PQS-21</td>
<td>16.1</td>
<td>5.6</td>
</tr>
<tr>
<td>PQS-22</td>
<td>22.1</td>
<td>13.9</td>
</tr>
<tr>
<td>EMA</td>
<td>20.3</td>
<td>15.3</td>
</tr>
<tr>
<td>EMC ex Blackmoor</td>
<td>15.7</td>
<td>9.3</td>
</tr>
<tr>
<td>EMC ex Keepers</td>
<td>17.0</td>
<td>7.0</td>
</tr>
<tr>
<td>SED (48 d.f.)</td>
<td>2.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Significance</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>LSD p=0.05</td>
<td>4.8</td>
<td>8.8</td>
</tr>
</tbody>
</table>

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

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

- PQS-6 has the highest cumulative yield in the trial and is only slight more vigorous that EMA (ns) but with a similar amount of > 55mm fruit produced.
- PQS-8, -18 & -22 all appear to be slightly more dwarfing than EMA with very similar total yields both in 2013 and cumulatively. However fruit size appears generally appears to be smaller and, in the case of PQS-22, yield efficiency is lower than in the controls.
• PQ5-12, previously identified as promising did not crop particularly well this year and whilst it is one of the most dwarfing entries, its cumulative yield so far is disappointing.

• PQ5-13 is one of the most promising dwarfing selections in this trial; with vigour similar to EMC and almost 75% of fruit produced > 55mm (compared with 50% for EMA). It also has the highest yield efficiency of the trial (significantly higher than EMA and EMC Keepers). It also appears a consistent cropper with the highest yield in 2012, when most selection produced almost no fruit.

• PQ5-16, also undergoing propagation, performed slightly worse than PQ5-18 in all categories.

Table 11.2. The yield pattern of Pyrus and Quince (QA and QC) rootstocks in 2010-13. (Plot DM178). Trees planted March 2006. Selections discussed in the main text are highlighted and those already in propagation are underlined.

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

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

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

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 include:

- **M.13**: dwarfing rootstock, parent of M.27 poorly characterise in resistance to many diseases but likely tolerant to replant disease
- **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** (M. 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, winter hardy, fairly fireblight resistant in the field, collar-rot resistant, moderate resistance to mildew and scab in the nursery
- **Geneva 11** (M26 x M. robusta 5): dwarfing (~ 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 M. 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 M. 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**: very good heat-tolerance, vigorous, productive, some susceptibility to nematodes, highly susceptible to mildew.
- **Evereste**: Ornamental Malus, source of fire blight resistance.
- **Torstein**: Scion cultivar, highly resistant to Phytophthora cactorum.
- **Novole**: North American accession of moderate to low vigour, reportedly resistant to *P. cactorum* as well as vole damage.
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 at least two controlled crosses will be carried out using parents from the list below in suitable combinations:

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

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