Project title:	East Malling Rootstock Breeding Club (EMRBC)
Project number:	TF 224
Project leader:	Felicidad Fernández, NIAB EMR
Report:	Annual report, 2016-2017
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Key staff:	Felicidad Fernández Adam Whitehouse
Location of project:	East Malling, Kent
Industry Representative:	Nigel Kitney, H L Hutchinsons Ltd
Date project commenced:	1 April 2015
Date project completed (or expected completion date):	31 March 2020

DISCLAIMER

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

AUTHENTICATION

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

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Signature Date: 27 September 2017

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GROWER SUMMARY

Headline

- NIAB EMR continues to breed and select 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.

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

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

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

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

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

Summary of the project and main conclusions

Preliminary trials

- 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. Some significant differences have started to emerge but, so far, none of these four selections appear particularly promising, especially as they are all susceptible to woolly apple aphid (WAA).
- Winter records were also taken in the trial of ten rootstocks for pear and significant differences found in all measures of vigour but these young trees did not crop in 2016.

Second stage trials

- In the conventional trial planted in 2010 (EE207), where five new selections are being evaluated with Braeburn and Gala for a vigour range between M.27 and M.26, full harvest and winter records were collected and significant differences were found for all parameters measured. AR852-3 continued to be of interest with similar tree size and yield efficiency to M9 but a higher cumulative yield of fruit > 65 mm in 'Braeburn'. R104 continued to produce the highest yield in Braeburn but on a larger tree than the controls requiring considerably more pruning. Differences in yield were smaller in the 'Gala' trial where M.9 continues to be the most productive rootstock.
- In the low-input orchard also planted in 2010 (VF224), the four selections being trialled are evaluated with Red Falstaff. Full harvest and winter measurements were collected. AR10-3-9 continues to perform very similarly to M.116. R80 continues to be the most productive rootstock and it also has the highest yield efficiency but it is also more vigorous that M.116 and MM106.
- The new trial evaluating Canadian rootstocks has now started cropping and differences are emerging on both vigour and productivity traits but it is too early to draw any conclusions.

Crossing programme

- Nine apple and two pear crosses were successfully carried out in spring 2016 and more than 2,600 seed were produced.
- Nearly 4,200 seeds from nine apple crosses and 2,674 from six pear families were sown in December 2016, from seed produced between 2010 and 2016.

Seedling populations

- A total of 1,782 apple seedlings from seven families raised in the last reporting period were planted in August 2016 through mypex.
- Seedling families planted in 2015 were budded in August 2016.

Selection

- Field records (vigour, crop load and suckering) were gathered from existing apple and pear populations.
- Forty preliminary selections were made from the population of apple seedlings (four families) planted in 2010. These have now been cut down to initiate propagation in 2017-18.

Pest and disease screening

- Fire-blight screening in Agroscope (CH) confirmed the full susceptibility of M.116 and AR10-3-9 and found AR120-242 to be even more susceptible than 'Gala'. On the other hand AR486-1 was found to have an intermediate susceptibility.
- For the first time, we can report a moderate success in our glasshouse testing for *P. cactorum* resistance.
- Screening for resistance to woolly apple aphid was particularly successful and a number of genotypes could be classed confidently with a few other needing re-testing in future.

Financial benefits

Although this is a long-term project, there are major financial advantages to the development and selection of rootstocks with improved agronomic performance including reduced pruning and picking costs and the ability to grow material with reduced pest and disease susceptibility.

Action points for growers

- There are no action points for growers at this stage of the project.

SCIENCE SECTION

Introduction

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, NIAB 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 (now NIAB EMR), the AHDB Tree Fruit Panel 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. The programme has been renewed several times since and current funding incorporating breeding, preliminary trialling and UK second stage trials runs until 2020.

For UK growers, the AHDB 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. AHDB also 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 in the EU (represented by EVI). 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 NIAB EMR, takes around 10 years. Promising material is then propagated and released for AHDB-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

Materials and methods

The breeding programme is an ongoing effort of which different steps are briefly described below. More detailed methodology is included in the relevant part of the yearly update if necessary.

Preliminary trials

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

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

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

Traditionally, rootstock trials at NIAB EMR have not been pruned other than to remove suckers after recording. However, this has not led to the best agronomical evaluation of the new selections. After discussions with the EMRC executive management committee and the AHDB Tree Fruit Panel, it was decided to correctively prune ongoing trials and to develop a conservative pruning strategy more in line with commercial orchard practice. Pruning weights were recorded in February 2015 and will continue to be so every winter until the end of the trial.

The best selections after this preliminary evaluation are subsequently propagated to enter the second stage trials funded by AHDB Horticulture under this same project (TF224) in the UK and by INN overseas.

Second stage trials (previously under AHDB Horticulture project TF172a&b):

Trials are performed as above but usually with greater level of replication as more material is available per genotype and, in the case of apple, can involve more than one scion cultivar. During the reporting year, three second state apple trials were evaluated (EE207 involving NIAB EMR genotypes in conventional growing conditions, VF224 involving NIAB EMR genotypes under low-input conditions and the recently planted SP250 that will assess

Breeding activities:

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. Seedlings are budded with a common scion 12-13 months after planting and the controls are bench grafted the winter after that and planted in the field during the second summer in the field of the seedling population.

Records on bud take and production of suckers are taken in the first two years of the population and, thereafter, for the three to four years, seedlings are evaluated with regards to vigour and suckering. As the common scion comes into fruit, crop load and fruit size are recorded and any other differences attributable to the rootstocks (e.g. incidence of bitter-pit) are noted if significant as is pest and disease incidence (in the suckers or crown) and any other detrimental characteristic observed (e.g. burr-knots, brittle wood, poor anchorage, etc.). The most promising seedlings on each population are selected for propagation usually five or six years after planting.

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 infestation by woolly apple aphid on families segregating for resistance)

Hardwood cuttings (ideally ~ 30 cm in length) are taken of these selections at the beginning of December and dipped in 0.5% (Indole-3-butryic acid) IBA solution for 5 s prior to insertion into a heated cutting bin to a depth of 6 to 8 cm. The cutting bin consists of 30 cm layer of a 1:1 mixture of peat and fine bark over a 5 cm layer of coarse sand. A soil warming cable maintains bed temperature at 25°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.

Pest and disease resistance screening

Fire-blight (FB)

Shoots of four selections were sent to Agroscope (CH) to be entered on their routine screening. Genotypes were grafted on rootstock M9vf T337 in rose pots (35.5 cm pot height, 7 cm in diameter, 12 replicate trees per genotype). 'Gala Galaxy' was included as a susceptible control, 'Enterprise' as a resistant control. Grafted genotypes were grown up during five weeks in a greenhouse (temperature: 16-24°C, humidity: 65%).

After five weeks, the plants were transferred to the security greenhouse GX. Plants with minimum shoot length of 14 cm were inoculated on early May 2016 as described by Momol et al. (1998). Inoculum *Erwinia amylovora* (Swiss strains FAW 610 Rif, specified concentration = 109 cfu/ml-1) was introduced to the shoot tip by inserting a syringe of 0.7 mm diameter (22 gauge) through the stem just above the youngest unfolded leaf. The length of the optical fire blight-free shoot part as well as the length of necrotic lesion (cm) was measured 7, 14 and 21 days after inoculation. To estimate susceptibility, percent lesion length (lesion length divided by shoot length) was calculated for each time point.

Woolly apple aphid (WAA)

Colonies of *Eriosoma lanigenum* (WAA) collected from the field in Kent are used to challenge rooted cuttings in the glasshouse. Aphids are added to each tree 2-3 times during July and August. Scoring is carried out at the end of the growing season. Individuals will be considered resistant if WAA failed to establish colonies and susceptible if they have succeeded. Genotypes considered resistant will usually be re-tested in a second season for confirmation as will any selection presenting conflicting results amongst replicates.

Phytophthora cactorum

The pot-based test for determining susceptibility to *P. cactorum* is still being developed. Following tests in 2014 and 2015, we were able to identify pathogenic isolates which were used in the 2016 screening of newly rooted hard wood cuttings as well as seedlings (details in the result section).

Replant disease

An area of fields at EMR is currently being set up to evaluate susceptibility of new germplasm to apple replant disease. It will initially compare the performance of a range of established cultivars (and EMR's most advanced selection AR295-6) on un-treated replant soil against that on virgin land and a replant site treated with chloropicrin. Germplasm from the Geneva programme was also sourced for this test in order to confirm the results of North-American trials in the UK. Future testing of advanced selections will depend on the results obtained over the next 2-3 yeas on this trial plot and the results of the NIAB EMR-led 'Apple Replant Disease Evolution and Rootstock Interactions' (ARDERI) project that started in April 2015 with funding from the BBSRC ‘Horticulture and Potato Initiative II’.

Results

Preliminary Trials

Apple trial (RF185)

Fruit was harvested form this trial in September 2016 and winter records completed in January 2017. Data from this trial is shown in Tables 1 and 2 and Figure 1.

In terms of rootstock effect there were significant differences in girth, tree volume and pruning weight, but not any significant effects in terms of yield, cumulative yield, yield efficiency or numbers of fruit produced. A summary of the performance of each rootstock is shown below:

M306-6 Although mean girth measurements, fruit size and yield were greater than in M116 these differences were not found to be significant. It gave the highest cumulative yield (ns), with a yield efficiency similar to MM106 and M116. Fruit size was better than with M116, with a higher percentage of large fruit (>55m: 99% for M306-6 v 77% for M116) Note: one tree was suffering from canker in 2016.

M306-20 As in 2015, the mean **tree volume** for this stock was **significantly greater** than all other stocks in the trial and had a significantly greater weight of wood removed during pruning). The total yield of M306-20 in 2016 was the second highest, as it was in 2015, only being surpassed by M306-6. This was reflected in the high cumulative yield, similar that was greater (but not significantly so) than the standards. However, as in previous years, **yield efficiency** was **relatively low**, comparable to M116.

M306-79 M306-79 was **similar to M9** in terms of vigour, with a similar mean girth and tree volume (slightly larger although not significant). In contrast to the previous two seasons (2014, 2015) it gave a slightly lower (ns) yield with a lower proportion of large fruit than M9 (>65mm: 57% for M306-79 v 87% for M9) although cumulative yield was very similar.

M306-189 This stock had a significantly narrower girth and **smaller tree volume** than the other stocks in the trial, with tree volume being approximately one-third of the volume of M9. Total and cumulative yields were lower than for all the other stocks, approximately half of that achieved with M9 (not significant) but yield efficiency was the highest (ns).

Table 1. The effects of apple rootstocks on the growth of 'Gala' apple trees in 2016 (Plot RF185). Trees planted March 2012

Rootstock	Girth (cm)	Tree volume (m^3)	Pruning weight (g)	Cumulative yield 2013-15 (kg)	Yield efficiency (kg/cm^2)
M306-6	13.2*a*	11.9*b*	871*a*	38.9	2.8
M306-20	13.8*a*	17.1*a*	896*a*	35.2	2.4
M306-79	9.3*b*	6.3*d*	239*b*	30.0	4.4
M306-189	6.0*c*	1.9*e*	171*c*	12.8	4.6
M9	8.7*b*	5.4*d*	311*bc*	26.2	4.5
MM106	11.0*b*	7.2*cd*	499*b*	30.7	2.9
M116	11.0*b*	9.7*bc*	578*b*	23.7	2.5
SED (17 d.f.)	*1.0*	*2.6*	*147.2*	*8.1*	*1.0*
Significance	***	***	***	*ns*	*ns*
LSD p=0.05	*2.1*	*4.3*	*310.5*	*7.1*	*2.1*

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

Table 2. The effects of apple rootstocks on the yield of 'Gala' apple trees in 2016 (Plot RF185). Trees planted March 2012

Rootstock	Mean yield per tree (kg)				Mean number of fruit per tree			
	≥65 mm	55-65 mm	<55 mm	Total	≥65 mm	55-65 mm	<55 mm	Total
M306-6	12.8	6.8	0.2	19.8	91	72	3	165
M306-20	5.7	9.7	2.4	17.8	43	111	40	194
M306-79	8.4	5.9	0.4	14.7	66	62	7	135
M306-189	3.5	1.9	0.2	5.6	28	22	4	53
M9	14.5	2.1	0.1	16.6	92	22	2	115
MM106	7.3	5.7	0.3	13.4	58	62	6	126
M116	1.5	6.6	2.4	10.5	13	74	62	149
SED (17 d.f.)	*4.5*	*3.6*	*1.0*	*5.3*	*32*	*41*	*26*	*57*
Significance	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
LSD p=0.05	*9.4*	*7.6*	*2.1*	*11.2*	*67*	*86*	*56*	*120*

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

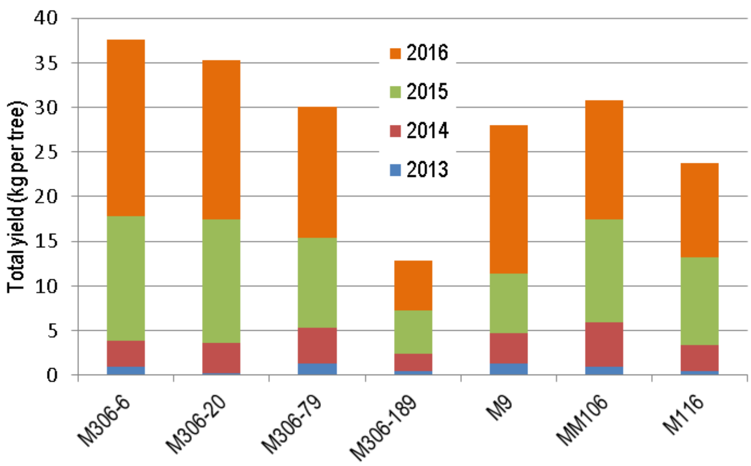


Figure 1. Total annual yields (kg per tree) from M306 series rootstocks and controls, with 'Gala' (Plot RF185) for 2013-16

Pear trial (RF187)

Winter records (height, girth, numbers of suckers and tree volume (cubic head m^3) were taken in January 2017, and a summary of this data is shown in Table 3.

In terms of rootstock effect there were significant differences in terms of girth, height and tree volume, but not any significant effects in terms of number of suckers. Two trees on PQ37-3 were dead, leaving only two replicates for analysis in the trial. Of note was **PQ37-5** that gave a significantly smaller tree in terms of girth, height and tree volume than all of the other selections tested. **PQ37-2** and **PQ39-5** had a significantly larger tree volume than the standard (Quince A). The remaining selections were otherwise not significantly different from the standard at this early stage of trialling. These results correlate well with those reported in 2015.

Table 3. The effects of pear rootstocks on the growth of 'Conference' pear trees in 2016 (Plot RF187). Trees planted August 2014

	Girth (cm)	Height (cm)	Number of suckers	Tree volume (m^3)
PQ37-2	11.6*a*	25.8*a*	0.0	2.5*a*
PQ37-3	6.5*d*	22.4*abc*	0.0	0.5*b*
PQ37-5	4.1*e*	11.0 *e*	0.0	0.1*c*
PQ37-7	10*abc*	20.3*bc*	0.0	0.7*b*
PQ37-8	7.2*d*	15.3*d*	1.0	0.5*b*
PQ38-2	7.1*d*	21.8*abc*	3.0	0.4*b*
PQ39-1	8.3*cd*	21.8*abc*	0.3	0.6*b*
PQ39-3	8.5*bcd*	20.0*c*	0.0	1.3*ab*
PQ39-4	7.1*d*	24.3*ab*	2.0	1.3*ab*
PQ39-5	10.8*ab*	21.8*abc*	0.0	2.5*a*
Quince A	10abc	23.8*abc*	0	1.2*b*
SED (28 d.f.)	*1.2*	*2.0*	*1.1*	*0.6*
Significance	***	***	*ns*	*
LSD p=0.05	*2.4*	*4.2*	*2.2*	*1.2*

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

Second stage trials

Conventional orchard, 'Braeburn' and 'Gala' (EE207)

Five East Malling Rootstock Club selections (AR852-3, AR839-9, B24, R104 and R59) were compared to M9, M26 and M27 under conventional management with 'Braeburn' and 'Gala' as scions. Fruit was harvested in September 2016 and winter records of tree growth and pruning weights were recorded in December 2016.

Braeburn

Significant differences were found in 2016 for all the parameters measured with the exception of mean fruit weight and numbers of suckers (Table 4-6), and a summary of the performance of each rootstock is shown below and in Figure 2:

AR852-3 AR852-3 was less productive than it had been in 2014 & 2015, but was yield was still comparable to M9 (Table 6). **Fruit size remained high**, with a higher proportion fruit of fruit >65mm being harvested (74% compared with 65% and 64% for M9 and M26 respectively). Yield efficiency and tree volume were similar to M9, but with a greater weight of prunings. **Cumulative total yield and yield efficiency were similar to M9, but with a higher cumulative yield of fruit >65mm**. As in 2015, numbers of suckers was very low.

AR839-9 This rootstock was **similar in most respects to M9** in 2016, giving a similar yield, proportion of fruit >65mm, tree girth and number of suckers. However tree volume and weight of prunings was slightly less than M9. **Total cumulative yield and yield efficiency were inferior to M9**.

B24 As in previous years, B24 had **significantly greater vigour** (tree volume) than all the other rootstocks as well as the highest pruning weight (Table 6). It also produced the **highest total yield in 2016**, with a yield and fruit size that were similar to that produced in 2015, the latter being a comparable size to the controls (Table 4). Total cumulative yield and cumulative yield of fruit >65mm, were similar to M9, however, **yield efficiency** (Table 5) was second **lowest** of all rootstocks assessed, having been the lowest in previous years.

R104 This stock exhibited greater vigour (tree volume) than both M26 and M9 but with a similar girth to M26, as in 2015. R104 had the second highest total yield in 2016, repeating the high-yielding pattern exhibited in 2013-15. Yield was much higher than for M26 but more similar to M9. In addition it gave the second **highest cumulative total yield** and a relatively high yield efficiency which was again higher than M26 and more similar to M9. Cumulative yield of fruit >65mm was greater than, with less suckering than the controls.

R59 **Similar** in most respects to **M27**, with comparable yield in 2016, but with a higher cumulative yield and yield efficiency. Tree volume and girth were similar to M27, but fruit size was **smaller fruit size** than M27 as in previous years. No suckers were produced by R59 in 2016 compared to a mean of 1.5 per tree from M27.

Table 4. Yield and numbers of fruit (means) produced from 'Braeburn' trees (Plot EE207, 2016) on rootstocks planted in 2010

	Yield (2016)				Mean fruit weight (g)
	Total (kg/tree)	Total (number/tree)	Class I >65mm (kg/tree)	Class I >65mm (number/tree)	
AR852-3	13.8	108.7	10.2	66.1	134
AR839-9	9.0	71.6	6.1	39.8	135
B24	20.1	157.7	13.6	88.0	130
M26	9.1	77.1	5.9	37.1	126
M27	4.8	47.6	1.6	10.6	125
M9	15.2	122.9	10.0	66.1	130
R104	17.6	138.1	11.9	74.7	139
R59	4.6	50.0	1.8	11.3	110
SED (44 df)	3.2	30.2	2.0	14.1	16
Rootstock	***	***	***	***	ns

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 5. Cumulative yield and yield efficiency of 'Braeburn' trees (Plot EE207, 2011-2016) on rootstocks planted in 2010.

	Cumulative yield 2010-16 (kg/tree)		Yield efficiency (kg / cm^2)
	Total	Class I >65mm	
AR852-3	86.3	41.8	5.7
AR839-9	51.5	23.5	4.3
B24	83.5	28.8	4.5
M26	65.8	25.0	4.8
M27	39.8	13.9	6.7
M9	84.9	29.7	6.1
R104	108.8	39.0	7.2
R59	49.1	12.7	8.8
SED (41 df)	12.6	5.4	1.2
Rootstock effect*	***	***	**

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 6. Growth measurements (means) of 'Braeburn' trees (Plot EE207, 2016) on rootstocks planted in 2010

	Girth (cm)	Tree Volume (m^3)	Suckers (No./tree)	Pruning weights (g/tree)
AR852-3	14.1	8.8	0.2	923
AR839-9	12.5	6.3	2.0	656
B24	15.4	15.1	0.1	1361
M26	13.8	7.1	0.7	790
M27	8.7	2.0	1.4	204
M9	12.9	8.5	1.5	493
R104	13.9	11.1	0.2	765
R59	8.7	1.9	0.0	132
SED (41 df)	1.0	1.7	0.9	154
Rootstock effect	***	***	ns	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

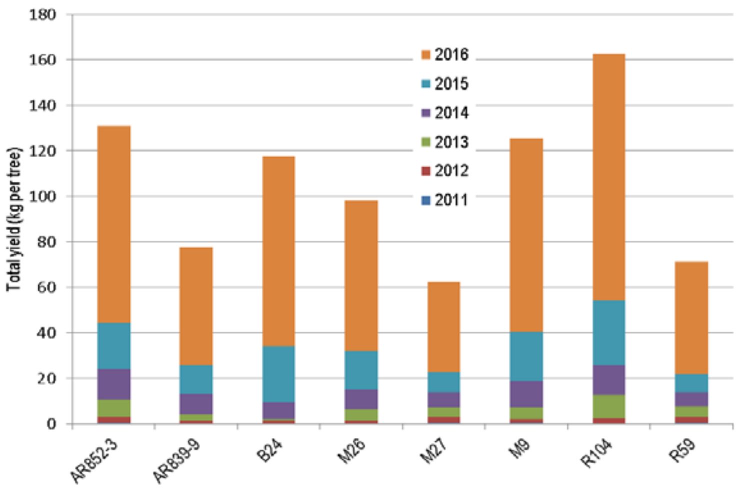


Figure 2. Total annual yields (kg per tree) from five EMRC rootstocks and controls, with ‘Braeburn’ (Plot EE207) for 2011-16

Gala

Significant differences were found in 2016 for all the parameters measured (Table 7-9), with the exception of mean fruit weight and total number of fruit. Controls with ‘Gala’ gave a greater performance in terms of total yield as with ‘Braeburn’ but yielded lower proportion of Class 1 fruit as they had done in 2015. A summary of the performance of each rootstock is shown below and in Figure 3:

AR852-3 As with ‘Braeburn’, AR852-3 gave a comparable (if not higher) total yield to M9 (Table 7). However fruit size was relatively small, in contrast to previous years’ results and those found with ‘Braeburn’ scion. Yield efficiency was greater than for M26, and more similar to M9. Vigour was greater than both M9 and M26, with a tree volume similar to that measured when grown with a ‘Braeburn’ scion.

AR839-9 This selection produced a total yield in 2016 that was slightly higher than both M9 and M26. Fruit size and the yield of proportion of fruit >65mm were similar to M9. Cumulative yield and yield efficiency were greater than for M26 but slightly less than for M9 (Table 8). Vigour (tree volume) was most similar to M9 with a comparable amount of suckers.

B24 As in 2015, B24 gave the **highest total yield** of all the stocks tested in 2016, and gave a cumulative total and Class 1 yield greater than for M9. However **yield efficiency** was significantly **lower** than both M9 (Table 8) which is attributable to the large **tree volume**, which was **significantly larger** than all the other stocks (Table 9).

R104 As with ‘Braeburn’ scions, R104 gave a relatively high yield in 2016, but yield of Class 1 fruit size was low (53% compared to 67% with M9) (Table 8). The high yield in 2015 and 2016 was not reflected in the cumulative yield that was lower than M9 and M26, and which may have contributed to the yield efficiency being the lowest of all the rootstocks tested. Vigour (tree volume) was most similar to M9, but with a larger girth and over double the pruning weight.

R59 As with ‘Braeburn’ R59 was **similar** in many respects to **M27**, with comparable tree volume and girth. However, unlike with ‘Braeburn’ it had a lower yield and **smaller fruit size** (mean fruit weight) than M27 in 2016. When considering cumulative yields and yield efficiency, R59 had a higher yield and efficiency than M27, although not significantly.

Table 7. Yield and number of fruit (means) produced from 'Gala' trees (Plot EE207, 2016) on rootstocks planted in 2010

	Yield (2016)				Mean fruit weight (g)
	Total (kg/tree)	Total (number/tree)	Class I >65mm (kg/tree)	Class I >65mm (number/tree)	
AR852-3	27.0	351.8	14.3	111.4	87
AR839-9	22.0	193.6	15.0	130.2	110
B24	32.2	378.1	16.7	128.4	96
M26	19.6	204.5	7.9	64.3	87
M27	9.3	339.5	3.4	30.7	71
M9	20.2	152.9	13.6	102.2	108
R104	28.2	330.3	15.0	122.1	93
R59	6.9	165.4	0.7	5.7	62
SED (38 df)	4.8	160.4	3.5	26.4	12
Rootstock effect*	***	ns	***	***	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 8. Cumulative yield and yield efficiency of 'Gala' trees (Plot EE207, 2011-2016) on rootstocks planted in 2010

	Cumulative yield 2010-16 (kg/tree)		Yield efficiency (kg / cm^2)
	Total	Class I >65mm	
AR852-3	95.2	35.0	6.3
AR839-9	82.8	36.0	5.9
B24	103.1	32.5	3.6
M26	75.7	24.0	4.8
M27	36.7	10.8	6.1
M9	101.4	30.3	7.6
R104	68.7	27.5	3.5
R59	43.7	8.0	7.7
SED (38 df)	15.3	6.2	1.0
Rootstock effect*	***	***	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 9. Growth measurements of 'Gala' trees (Plot EE207, 2016) on rootstocks planted in 2010

	Girth (cm)	Tree Volume (m^3)	Suckers (No./tree)	Pruning weights (g/tree)
AR852-3	13.8	9.3	0.0	1377
AR839-9	13.5	8.2	2.8	1219
B24	18.6	15.0	0.0	2231
M26	13.9	6.5	2.7	905
M27	8.7	2.1	1.4	253
M9	13.1	7.7	0.8	550
R104	15.3	7.5	0.0	1231
R59	8.5	2.0	0.6	354
SED (38 df)	1.0	1.8	1.2	347
Rootstock effect	***	***	**	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

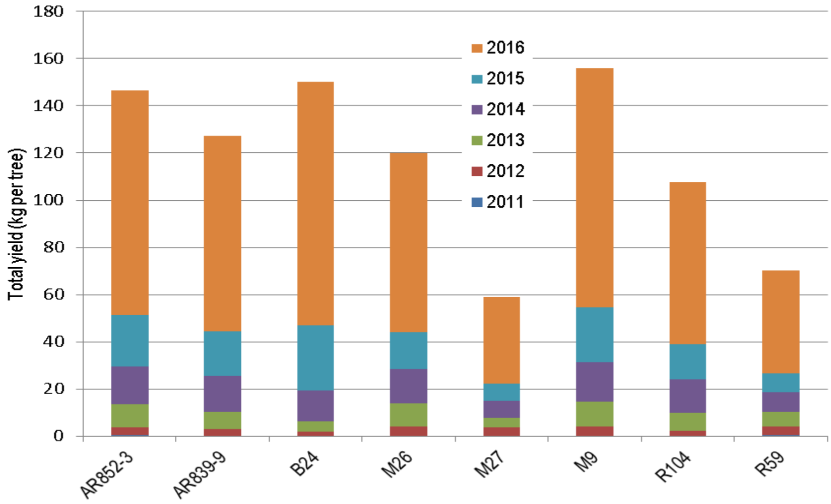


Figure 3. Total annual yield (kg per tree) from five EMRC rootstocks and controls, with 'Gala' (Plot EE207) for 2011-16

Low input/Organic orchard, 'Red Falstaff' (VF224)

Five East Malling rootstock club selections (AR10-3-9, AR809-3, AR835-11 and R80) were compared to M116 and MM106 under organic management with Red Falstaff as the scion variety. Fruit was harvested in September 2016 and winter records of tree growth and pruning weights were recorded in December 2016. In 2015, as we started examining fruit for bitter-bit and other blemishes, it was noted that the scion ('Red Falstaff') was not true-to-type in two of the trees in this trial; data for these have been omitted from the results, including cumulative data from previous years.

AR10-3-9 AR 10-3-9 was similar to M116 in terms of vigour and yield efficiency, but with a slightly lower yield, both in 2016 of and cumulatively, although this was not significant.

AR809-3 Significantly smaller girth size and tree volume than all the other rootstocks tested as has been noted in the previous years (2012-2015). Yield was lower in every category than all other rootstocks tested, although was similar to the other stocks except R80.

AR835-11 Largest tree volume, significantly greater than all other stocks with the exception of R80. It gave a total yield in 2016 that was slightly higher than M116. Fruit size was large, as noted in previous years, with 60% of the total yield being in the >65m category compared to 44% with M116. Total cumulative yield and yield efficiency were similar to M116, but cumulative yield of large fruit (>65mm) was significantly greater than M116.

R80 Produced a high total yield as it had in previous years, and which was significantly higher than AR809-3 and MM106. This high yield was mirrored in its cumulative yield which was greater than all the other stocks in the trial. However this was combined with a large tree volume which was larger than MM106, and only surpassed in volume by AR835-11.

Table 10. Yield and number of fruit produced from 'Red Falstaff' trees (Plot VF224, 2016) on rootstocks planted in 2010

	Yield (2016)				Mean individual fruit weight (g)
	Total (kg/tree)	Total (number/tree)	Class I >65mm (kg/tree)	Class I >65mm (number/tree)	
AR10-3-9	10.2	111.8	4.7	37.3	95
AR809-3	5.9	75.6	2.2	18.6	84
AR835-11	12.9	137.6	7.4	58.4	96
R80	12.3	124.3	7.4	56.8	101
M116	11.5	126.0	5.1	40.5	93
MM106	10.1	119.7	3.6	31.2	84
SED (32 df)	1.4	17.2	1.3	9.7	9
Rootstock effect	***	*	***	*	ns

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 11. Cumulative yield and yield efficiency of 'Red Falstaff' trees (Plot VF224, 2011-2016) on rootstocks planted in 2010

	Cumulative yield 2011-16(kg/tree)		Yield efficiency (kg / cm^2)
	Total	Class I >65mm	
AR10-3-9	18.9	8.1	1.1
AR809-3	11.5	4.6	1.3
AR835-11	20.6	12.1	1.3
R80	25.4	12.2	1.8
M116	20.1	7.8	1.1
MM106	18.4	7.2	1.3
SED (32 df)	2.7	1.8	0.2
Rootstock effect	***	***	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

Table 12. Growth measurements on 'Red Falstaff' trees (Plot VF224) on rootstocks planted in 2010

	Girth measurements (cm)	Tree Volume (m^3)	Pruning weights (g/tree)
AR10-3-9	14.4	9.2	392.4
AR809-3	10.4	4.0	172.2
AR835-11	14.3	14.5	583.7
R80	13.4	10.5	443.6
M116	15.1	8.9	426.2
MM106	13.2	7.5	225.6
SED (32 df)	0.8	1.8	85.7
Rootstock effect	***	***	***

*rootstock effect was either non-significant (ns) or significant at the 5 (*), 1 (**) or 0.1% (***) level of probability

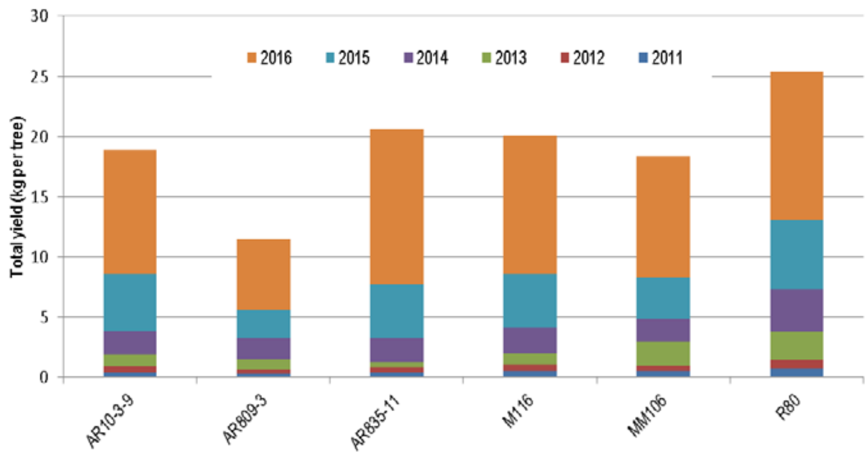


Figure 4. Total annual yields (kg per tree) from five EMRC rootstocks and controls, with 'Red Falstaff' (Plot VF224) for 2011-16

<u>Conventional apple trial – Canadian rootstocks; Gala & Braeburn (SP250):</u>

Nine Canadian rootstocks (SJM127, SJM167, SJM188, SJP84-5217, SJP84-5162, SJP84-5174, SJM15, SJM189 and SJP84-5231) were compared to M9, M26, M27 and MM106 under conventional management with 'Braeburn' and 'Gala' as scions. Fruit was harvested in September 2016, weighed and graded. Bitter pit incidence was recorded on a subjective scale from 1-5 (1 = none affected, 2 = 5%, 3 = 5-20%, 4 = 20-50% and 5 = > 50% affected). Winter records of tree growth and pruning weights were recorded in January 2017.

Out of 198 trees (including those in guard rows), 20 individual rootstocks were previously shown to not be true-to-type; eight scions had been mislabelled and one tree was wrongly labelled for both scion and rootstock. This has resulted in an unbalanced experimental design and some of the rootstocks are only present with one of the two scion varieties (only 'Braeburn': SJM127, SJM188 and SJP84-5162; only 'Gala': SJM15, SJM189 and SJP84-5231

Yield efficiency is presented both as a function of tree volume (kg/m^3) and of the trunk cross-sectional area (TCA) in kg/cm^2. All parameters were statistically analysed using REML and Fisher's unprotected LSD in Genstat.

Braeburn

SJM127 The fruits from 'Braeburn' on this rootstock had a significantly higher incidence of bitter pit compared to M26, M27 and MM106 (Table 13). The tree size was comparable to M9 and MM106. However, the **vigour of M9 on 'Braeburn'**, which exceeded MM106, **was higher in this trial than what is normally expected**. SJM127 had higher means of total yield and yield efficiency than both M9 and MM106 (Table 14). The proportion of class I fruit yield was 92% of the total yield.

SJM167 The tree volume of this rootstock was comparable to M9 and MM106 in this trial. The total yield was higher compared to all standards, but not significantly so. Yield efficiency as a function of TCA (kg /cm^2) was significantly higher than for MM106 but no significant difference was found between them when yield efficiency was calculated in relation to tree volume (kg/m^3).

SJM188 This selection produced trees with volume and girth between that of trees on M26 and MM106, but with a higher total yield compared to the same standards. The TCA yield efficiency (kg/cm^2) was significantly higher than for MM106 but not different from M26. However, SJM188 had a relatively low proportion of Class I fruit (84%) compared to M26 and MM106 (94 and 96%, respectively).

SJP84-5217 This rootstock had the largest mean tree volume and girth of all of the rootstocks trialled with 'Braeburn' (Table 13) but, under the moderate pruning parameters of these trials, the pruning weight was approximately half those for MM106 and similar to M9. The mean total yield was larger than for any of the standards (n.s.). TCA yield efficiency (kg/cm^2) was higher than for MM106 and not significantly different to that of the other standards.

SJP84-5162 The mean tree volume was between of M26 and MM106 (4.5 m^3). The total mean yield of SJP84-5162 was the same as for M26 (5.6 kg/tree) with 54% of the fruit yield graded as 70-75 mm and 31% as 75-80 mm.

SJP84-5174 The tree vigour of this rootstock exceeded MM106 and it had the highest total yield of 'Braeburn' of all of the trialled rootstocks. The proportion of Class I 'Braeburn' fruit (>65 mm) of the total yield was 98 %. The total number of fruits and the yield efficiency of SJP84-5174 were also higher compared to MM106, but not significantly so.

Gala

SJM15 The yield efficiency—both in relation to tree volume (kg/m^3) and TCA (kg/cm^2)—of SJM15 was higher compared to the other rootstocks trialled with 'Gala'. The differences between SJM15 and MM106, M9 and M26 in yield efficiency were statistically significant ($p \leq 0.05$). 'Gala' trees on SJM15 also had the highest mean yield (n.s.). The tree volume of this selection was smaller than for MM106 ($p \leq 0.05$), and slightly but not significantly smaller than M9 and M26 (Table 14**)**.

SJM167 As with 'Braeburn', trees on SJM167 had similar girth size and vigour to those on MM106. The total yield for 'Gala' trees on SJM167 was higher than on MM106, although the yield efficiencies were similar. 'Gala' had a lower **incidence** of bitter pit when grown on SJM167 compared to all other rootstocks. However, this difference was not statistically significant.

SJM189 SJM189 had a similar tree volume to M26, but the mean girth was narrower. The selection had higher yield efficiency (both kg/m^3 and kg/cm^3) than M9, M26 and MM106. However, this difference was not statistically significant.

SJP84-5217 The rootstock was similar in vigour and girth to MM106. The pruning weight of 'Gala' trees on SJP84-5217 was around half of the pruning weight of MM106. The selection had higher yield efficiency (both kg/m^3 and kg/cm^3) than M9, M26 and MM106 (this difference was not statistically significant), but a lower yield efficiency than M27.

SJP84-5231 The yield efficiency —both in relation to tree volume (kg/m^3) and TCA (kg/cm^2)—of SJP84-5231 surpassed M9, M26 and MM106 (this difference was not statistically significant), but was lower than for M27. The tree volume and girth of the rootstock was comparable to SJM15 (somewhere between M27 and M9).

SJP84-5174 The high total yield produced with 'Braeburn' for this rootstock was not repeated in 'Gala', where it had comparable yields to M27 but a significantly larger tree volume than this standard and more similar to M9.

Table 13. Mean growth measurements and bitter-pit severity of 'Braeburn' and 'Gala' trees planted in 2014. Letters denote statistically significant differences at $p \leq 0.05$

Rootstock	Girth (cm)	Tree volume (m^3)	Pruning weight (g/tree)	Number of suckers (No./tree)	Bitter pit incidence
Braeburn					
M9	9.2, *efghi*	5.8, *hijk*	428, *fgh*	0.0	1.8, *fgh*
M26	9.2, *efghi*	3.7, *bcde*	336, *efg*	0.1	1.6, *defg*
M27	6.5, *ab*	1.9, *ab*	119.5, *abc*	0.0	1.1, *abcde*
MM106	10.8, *j*	5.0, *defghijk*	811, *h*	0.2	1.6, *bdefg*
SJM127	9.7, *hij*	5.2, *efghijk*	360, *efgh*	0.2	2.3, *h*
SJM167	9.5, *fhj*	5.5, *ghijk*	239, *cdef*	0.0	1.7, *efg*
SJM188	8.3, *cdef*	4.4, *cdefgh*	283, def	0.0	1.8, *fgh*
SJP84-5217	9.8, *hij*	6.7, *ik*	405, *fgh*	0.0	1.5, *bcdefg*
SJP84-5162	8.4, *cdefg*	4.5, *defgh*	391, *fgh*	0.0	1.9, *gh*
SJP84-5174	9.2, *efghi*	5.6, *fghijk*	640, *gh*	0.0	1.4, *abcdefg*
Gala					
M9	8.8, *defgh*	3.7, *bcdef*	214, *cdef*	0.1	1.0, *abc*
M26	9.7, *hij*	3.2, *bcd*	155, *bcd*	0.1	1.0, *abcd*
M27	6.0, *a*	0.8, *a*	56, *a*	0.1	1.0, *abcd*
MM106	10.0, *ij*	4.8, *defghij*	304, *def*	0.0	1.1, *abcd*
SJM15	7.4, *bc*	2.3, *abc*	111, *abc*	0.2	1.4, *abcdefg*
SJM167	9.8, *hij*	4.7, *defghi*	351, *defgh*	0.0	0.8, *a*
SJM189	8.1, *cde*	3.1, *bcd*	100, *ab*	0.0	1.0, *ab*
SJP84-5217	9.6, *fhij*	4.6, *defgh*	175, *bcde*	0.2	1.2, *abcdef*
SJP84-5231	7.7, *bcd*	2.4, *abc*	116, *abc*	0.0	0.9, *a*
SJP84-5174	8.9, *defghi*	3.8, *bcdefg*	183, *bcde*	0.0	1.0, *abcd*
Effect of rootstock:scion	***	***	***	n.s	***

Table 14. Mean yield, number of fruits and yield efficiency of 'Braeburn' and 'Gala' trees planted in 2014. Letters denote statistically significant differences at p ≤ 0.05

Rootstock	Total yield (kg/tree)	Total number of fruit (no./tree)	Yield efficiency	
			yield/girth (kg/cm²)	yield/tree volume (kg/m³)
Braeburn				
M9	1.4	25	0.8, *abc*	0.9, *a*
M26	5.6	42	1.1, *bc*	2.0, *bcd*
M27	1.5	34	1.3, *cd*	2.5, *cde*
MM106	2.7	23	0.4, *a*	0.8, *a*
SJM127	5.8	48	1.0, *abc*	1.4, *ab*
SJM167	6.9	44	1.1, *bc*	1.6, *abc*
SJM188	7.4	45	1.3, *cd*	1.7, *abcd*
SJP84-5217	7.1	48	1.1, *bc*	1.3, *ab*
SJP84-5162	5.6	42	1.3, *cd*	1.7, *bcd*
SJP84-5174	10.6	45	1.2, *cd*	1.6, *abc*
Gala				
M9	5.5	38	0.9, *abc*	1.7, *bcd*
M26	5.4	33	0.7, *ab*	1.5, *abc*
M27	3.2	27	1.4, *cd*	4.0, *e*
MM106	6.8	47	0.9, *abc*	1.4, *ab*
SJM15	9.0	65	1.8, *d*	4.1, *e*
SJM167	8.5	39	0.8, *abc*	1.3, *ab*
SJM189	6.5	43	1.2, *bc*	2.1, *bcd*
SJP84-5217	6.9	57	1.1, *bc*	1.8, *bcd*
SJP84-5231	5.4	47	1.4, *cd*	2.8, *de*
SJP84-5174	3.7	32	0.9, *abc*	1.3, *ab*
Effect of rootstock:scion	n.s	n.s	*	***

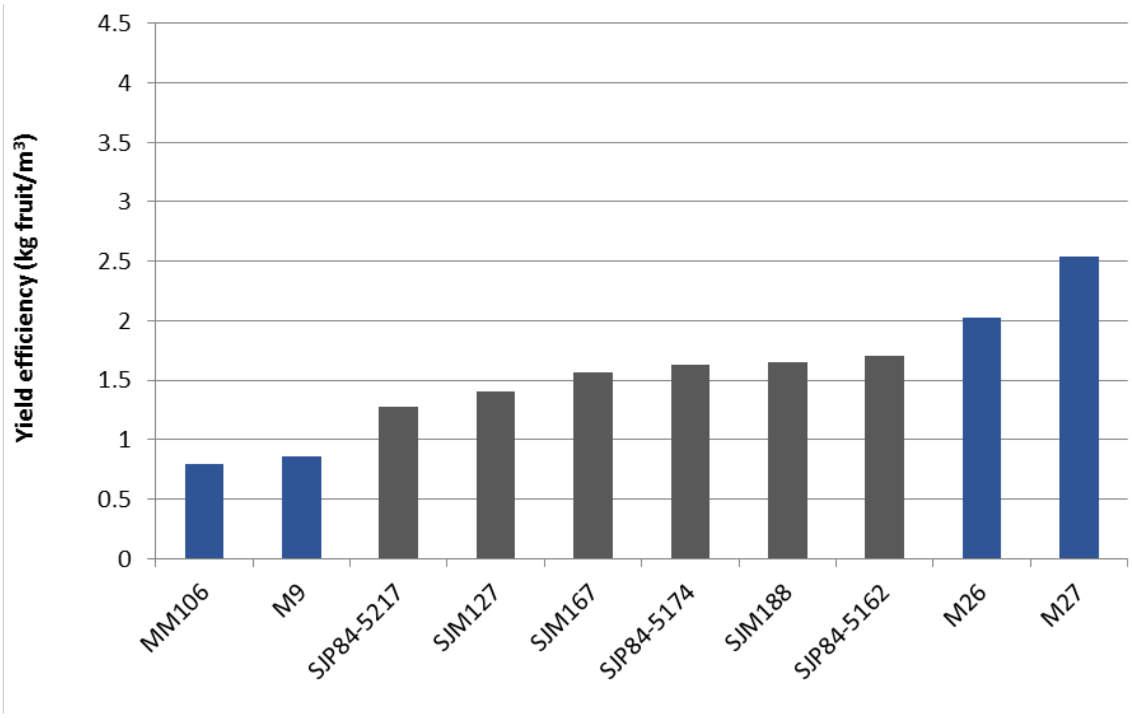


Figure 5. Yield efficiency as a function of tree volume of ‘six Canadian rootstocks and four standards with ‘Braeburn’ as a scion. Trees planted in 2014

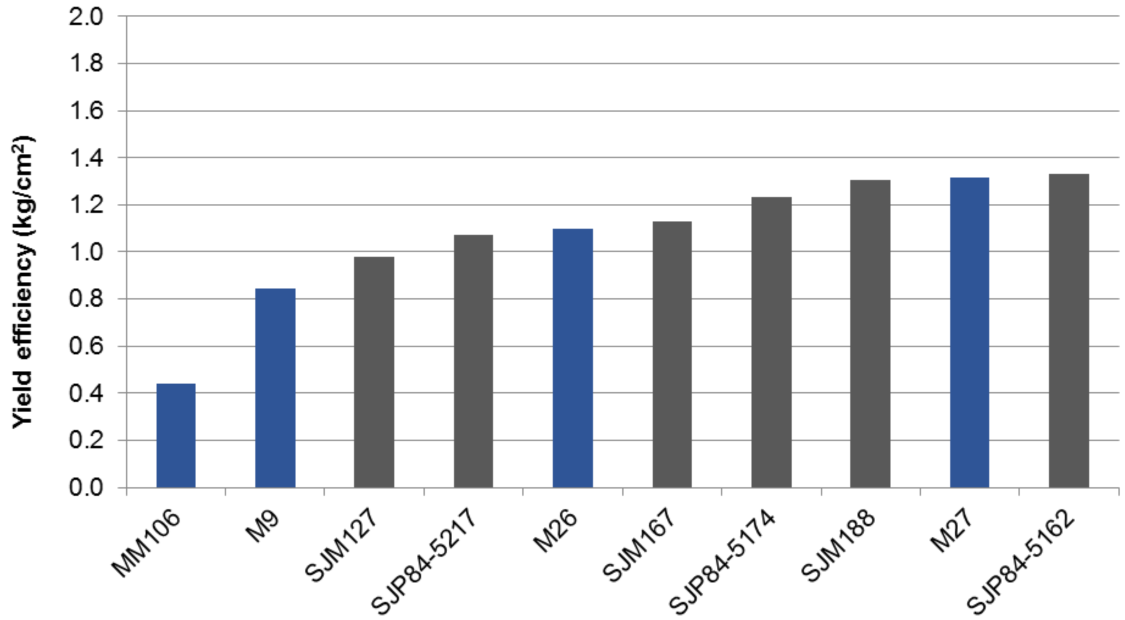


Figure 6. Yield efficiency as a function of trunk cross-sectional area (TCA) of ‘six Canadian rootstocks and four standards with ‘Braeburn’ as a scion. Trees planted in 2014

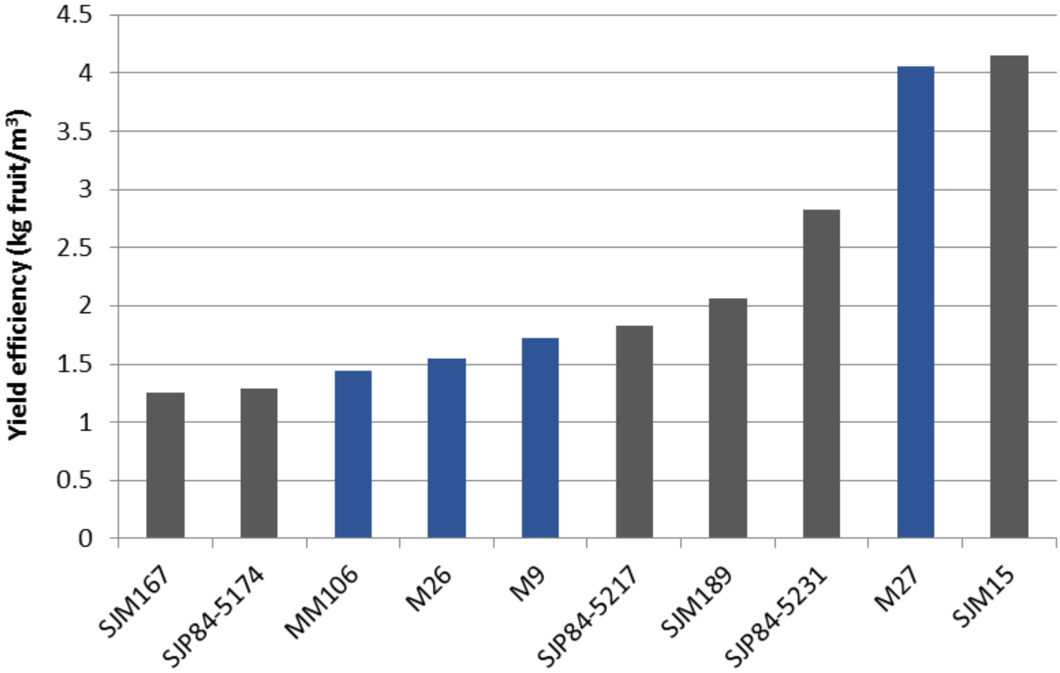


Figure 7. Yield efficiency as a function of tree volume of 'six Canadian rootstocks and four standards with 'Braeburn' as a scion. Trees planted in 2014

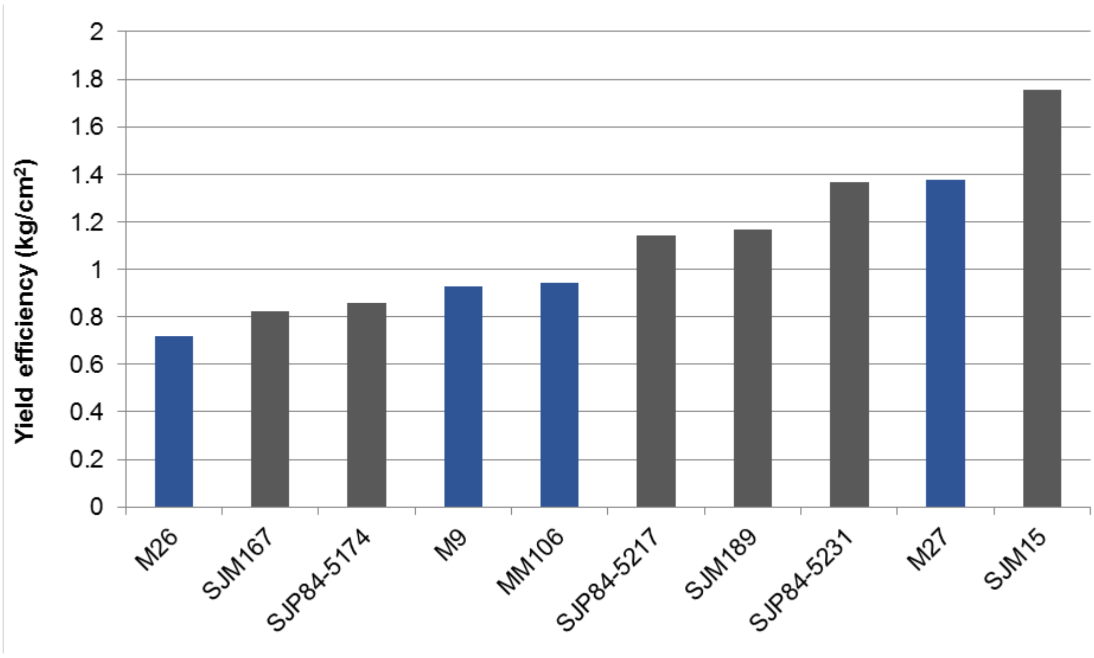


Figure 8. Yield efficiency as a function of tree volume of 'six Canadian rootstocks and four standards with 'Gala' as a scion. Trees planted in 2014

Figure 9. Yield weight shown by fruit size for 'Braeburn' (Plot SP250) on ten different rootstocks

Figure 10. Yield weight shown by fruit size for 'Gala' (Plot SP250) on ten different rootstocks.

Breeding activities

New seedling populations

A total of 1,782 new apple seedlings from seven different families (Table 15) were planted in August 2016 through mypex in double rows. They will be budded late August or early September 2017 with a common scion for field evaluation. Control rootstock varieties for this plot will be grafted in February 2018 to be planted out the following autumn.

No pear seedlings were raised in 2016.

Table 15. Apple rootstock seedlings planted in 2016

Family	Cross	Year of crossing	Seeds sown	Planted (Aug 16')
M595	A469-4 x MH.12.3	2014-15	143	87
M596	M.13 x Bud.9	2014-15	384	291
M598	Evereste x AR295-6	2015	500	440
M599	Novole x AR295-6	2015	495	120
M600	Bud 9 xEvereste	2015	504	420
M601	M.116 x AR295-6	2015	255	218
M602	M.13 x Geneva 11	2015	227	206
		Total	2508	1782

Crossing and germination

The crossing programme was carried out from early April to mid May 2016. Fruit set was acceptable in both apple and pear crosses but probably negatively affected by a late spring frost.

A total of 2,343 apple seeds from seven different crosses were produced in 2016 (Table 16). The three crosses highlighted in Table 16 will be repeated in 2017 and 2016 seed stored to germinate at the same time.

For pears, 229 seed from two different crosses were produced in 2016; one of the four crosses carried out completely failed and another set fruit but yielded no seeds (Table 17). As in previous years, the diploid 'Pyronia' tree completely failed to set fruit and will only be used, if at all, as a pollen source in future.

Table 16. Apple crosses made in 2016. Numbers of flowers pollinated, fruits collected as well as seeds extracted, aborted those viable to be stores are given. Crosses highlighted in green will be repeated in 2017

Cross	Flowers pollinated	Fruits harvested	Seeds extracted	Aborted seeds	Viable seeds stored
Evereste x Geneva 11	408	127	335	42	293
Geneva 30 x AR440-1	434	49	160	71	89
M.13 x AR295-6	297	101	526	57	469
M116 x AR295-6	188	13	69	14	55
Bud 9 x Evereste	276	184	786	50	736
Geneva 11 x AR295-6	53	5	16	6	10
AR295-6 x Geneva 30	333	N/A	793	102	691
Total	1,989		2,685	342	2,343

Table 17. Pear crosses made in 2016. Numbers of flowers pollinated, fruits collected as well as seeds extracted, aborted those viable to be stores are given. Crosses highlighted in green failed to yield any seed

Cross	Flowers pollinated	Fruits harvested	Seeds extracted	Aborted seeds	Viable seeds stored
OHxF333 x Farmingdale	148	85	214	43	171
OHxF69 x BP2	117	27	0	0	0
Old Home x BP3	162	48	91	33	58
Pyronia (2n) x OHxF51	63	0	0	0	0
Total	490	160	305	76	229

A total of 4,190 apple (nine families) and 2,674 pear seeds (six families) were sown in December 2016 (Table 18-19); these families included seed from crosses made between 2010 and 2016.

Seeds were stratified at 2°C for 14 weeks. In March 2017, they were transferred to a heated glasshouse (Day Tm > 18 °C, Night Tm >15°C) with supplementary lighting, as needed for 16h day light to be planted out in the summer of 2017.

Table 18. Apple seeds sown in 2016 by family; parentage and the year(s) the seed was produced is indicated

Family	Parentage	Year(s) of crossing	Sown
M603	AR86-1-20 x C.G.11	2010	200
M604	M.9 x M.116	2013	61
M605	Novole x M.116	2014	98
M606	Evereste x C.G. 202	2015	542
M607	Evereste x C.G. 11	2016	293
M608	Evereste x AR295-6	2015	976
M609	M.13 x AR295-6	2015&2016	505
M610	Bud 9 x Evereste	2016	736
M611	AR295-6 x C.G. 30	2015&2016	779
Total			4,190

Table 19. Pear seeds sown in 2016 by family; parentage and the year(s) the seed was produced is indicated

Family	Parentage	Year(s) of crossing	Sown
PRP57	BP1 x P. betulifolia	2010	1,150
PRP58	OHxF333 x Junsko Zlato	2010	821
PRP59	OHxF51 x Pyronia (2n)	2015	236
PRP60	Old Home x BP3	2015&2016	227
PRP61	OHxF69 x BP2	2015	69
PRP62	OHxF333 x Farmingdale	2016	171
Total			2,674

Evaluation of existing seedling populations

Apple

Nineteen families (listed below) were assessed by breeders in September 2016. Records on vigour, crop load and suckering were taken as appropriate and, in certain genotypes, fruit size and other traits such as the incidence of burr-knot were also recorded. Woolly apple aphid colonization was also noted and susceptible seedlings from families segregating for resistance to this pest were deselected.

Planted 2010 (plot SC198):

- M553 (AR86-1-20 x C.G.202)
- M554 (M.M.106 x C.G.30)
- M555 (C.G.30 o.p.)
- M556 (Ottawa 3 o.p.)

Planted 2011 (plot SC199):

- M557 (M.116 x M.9)
- M558 (C.G.30 x M.116)
- M559 (Bud 9 x M.9)
- M560 (AR86-1-20 x C.G.11)
- M561 (M.27 x C.G.30)
- M562 (M.M.106 x C.G.202)
- M563 (M.M.106 x Bud 9)

Planted 2012 (plot SP241):

- M555a (C.G.30 o.p.)
- M556a (Ottawa 3 o.p.)
- M559a (Bud 9 x M.9)
- M560a (AR86-1-20 x C.G.11)
- M561a (M.27 x C.G. 30)
- M562a (M.M.106 x C.G.202)
- M563a (M.M.106 x Bud 9)
- M564 (C.G.202 x AR295-6)
- M565 (Bud 9 x M.116)

Preliminary selections had been made in 2015 from families planted in 2011 (M553 - M556) and following final evaluation in 2016 some of those were discarded and additional selections made (Table 20). All selected seedlings were cut down below graft union in winter 2016-17 further propagation (Table 20). Remaining families will continue to be assessed in 2017 season.

Seedling families planted in 2013 (M566, M567, M568, M569, M570, M571 and M572) were scored for vigour, suckering and, for first time, crop load. 2014 plantings were assessed for suckering and bud take only.

Pear

Six pear families planted in 2012 (below) were also assessed in September 2016 but none were deem sufficiently mature for selections to be made. Records were taken on vigour; suckering and crop load and, in some cases, fruit size.

Planted 2011 (Plot SC200):

- PRP45 (PB11030 x OHxF87)
- PRP46 (B14 x op)
- PRP47 (BP1 x P. betulifolia)
- PRP48 (OHxF333 x Junsko Zlato)
- PRP49 (PB11030 x OHxF333)
- PRP50 (OHxF87 x BP1)

Records on vigour and suckering were also taken on four families planted in 2013 (SF247).

Table 20. Apple seedlings selected in 2015 & 2016, based on four year data on vigour, crop load, suckers and any additional observations such as woolly apple aphid susceptibility, burrknots and in 2016 fruits size. Vigour was scored as very weak (vw), weak (w), medium weak (mw), medium (m), medium vigorous (mv), vigorous (v) and very vigorous (v v). Crop load was graded as none (0), very low (vl), low (l), medium low (ml), medium (m), medium high (mh), high (h), very high (vh). Suckers were assessed as none (0), few (+), plenty (++), many (+++). Selections highlighted in yellow were chosen exclusively as parental lines

Selection	Crossed	Planted	Budded	Vigour				Crop Load				Suckers				Selected	Cut-down
				2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016		
M553-02	2009	2010	2012/13	mw	mw	mw	mw	0	l	h	vh	++	+	+	+	2015&16	Mar 17
M553-28	2009	2010	2012/13	vw	vw	0	w	0	0	0	h	0	0	0	+	2016	Mar 17
M553-32	2009	2010	2012/13	mv	0	mv	mv0v	0	0	l	h	0	+	0	0	2016	Mar 17
M553-36	2009	2010	2012/13	mw	0	mw	mw	0	0	h	h	0	0	+	0	2016	Mar 17
M553-52	2009	2010	2012/13	w	w	w	m	0	0	0	mh	++	++	++	++	2015&16	Mar 17
M553-53	2009	2010	2012/13	w	w	0	mw	0	0	0	ml	+	+	0	++	2016	Mar 17
M553-64	2009	2010	2012/13	mv	m	mw	mw	0	l	l	h	0	+	+	+	2015&16	Mar 17
M553-77	2009	2010	2012/13	w	vw	0	w	0	0	0	mh	+	+	0	+	2015&16	Mar 17
M553-83	2009	2010	2012/13	w	w	0	mw	0	0	0	ml	0	0	0	+	2016	Mar 17
M553-85	2009	2010	2012/13	mv	m	0	m	0	m	0	h	0	0	0	0	2016	Mar 17
M553-107	2009	2010	2012/13	mv	mw	m	m	0	l	mh	0	++	++	+++	+++	2016	Mar 17
M553-112	2009	2010	2012/13	mw	w	mv	mv	0	vl	m	h	+	0	0	0	2016	Mar 17
M553-117	2009	2010	2012/13	m	mv	0	m	0	0	0	vh	0	0	0	0	2016	Mar 17
M553-124	2009	2010	2012/13	mw	w	0	w	0	0	0	mh	+	++	0	+	2016	Mar 17
M553-127	2009	2010	2012/13	mw	w	0	mw	0	0	0	mh	+	+	0	0	2016	Mar 17
M554-17	2009	2010	2012/13	w	mw	m	m	0	0	mh	h	0	0	0	0	2015&16	Mar 17
M554-40	2009	2010	2012/13	w	w	0	m	0	l	0	mh	++	++	0	++	2016	Mar 17
M554-72	2009	2010	2012/13	m	m	0	m	0	0	0	h	++	++	0	+	2016	Mar 17
M554-92	2009	2010	2012/13	m	mv	mv-m	m	0	l	m	h	0	+	+	+	2015&16	Mar 17
M554-95	2009	2010	2012/13	mw	mw	0	mv	0	0	0	h	+	+	0	++	2016	Mar 17
M554-135	2009	2010	2012/13	w	0	mw	m	0	0	0	h	0	+	+	++	2016	Mar 17
M554-209	2009	2010	2012/13	w	0	w	w	0	0	0	h	+	+	+	+	2016	Mar 17
M554-214	2009	2010	2012/13	m	m	m	mv	0	l	m	vh	0	0	++	++	2016	Mar 17
M554-264	2009	2010	2012/13	mw	mw	m	m	0	0	l	h	+	+	+	+	2016	Mar 17
M554-343	2009	2010	2012/13	w	0	w	w	0	0	l	m	0	0	+	+	2016	Mar 17
M555-30	2009	2010	2012/13	m	mw	mv	m	0	0	m	m	+	0	+	0	2015&16	Mar 17
M555-85	2009	2010	2012/13	mw	mw	mw	m	0	0	mh	l	0	0	0	0	2015	Mar 17
M555-122	2009	2010	2012/13	w	vw	0	w	0	0	0	h	+	++	0	+	2016	Mar 17
M555-136	2010	2010	2012/13	w	0	w	vw	0	0	0	m	+	0	0	0	2016	Mar 17
M555-185	2010	2010	2012/13	mw	0	m	mv	0	0	mh	h	0	0	+	++	2016	Mar 17
M555-189	2010	2010	2012/13	mw	w	0	w	0	0	0	h	0	0	0	+	2016	Mar 17
M555-252	2010	2010	2012/13	m	m	0	mv	0	0	0	mh	+	++	0	+	2016	Mar 17
M555-282	2010	2010	2012/13	m	mw	w	m	0	h	vl	h	0	0	+	0	2016	Mar 17
M556-7	2010	2010	2012/13	m	mw	0	w	0	m	0	vh	+	+	0	++	2016	Mar 17
M556-36	2010	2010	2012/13	mw	w	0	w-vw	0	0	0	vh	0	+	0	++	2016	Mar 17
M556-45	2010	2010	2012/13	m	mw	w	w	0	l	0	mh	+	0	+++	+++	2016	Mar 17
M556-46	2010	2010	2012/13	m	m	mv	m	0	0	vh	h	+	+	+	+	2015&16	Mar 17
M556-52	2010	2010	2012/13	w	w	0	w	0	0	0	ml	0	0	0	0	2016	Mar 17
M556-165	2010	2010	2012/13	vw	vw	mw	w	0	0	0	h	+	0	+	0	2016	Mar 17
M556-191	2010	2010	2012/13	m	m	0	m	0	vl	0	h	0	0	0	0	2016	Mar 17

Pest and disease resistance screening

Fire blight (FB)

Three EMR advanced selections (Table 21) and M.116 were tested at Agroscope (CH) in 2016 of which only AR10-3-9 previously had been tested previously. The other three genotypes had not tested in this facility before. Graft-wood from these genotypes was sent to Wädenswil in January for inoculation and monitoring by Markus Kellerhals's team.

Table 21. Apple genotypes to be tested for FB resistance in 2016 by Agroscope

Genotype	Parentage	Previous data on response to FB	No. of shoots tested
AR486-1	Ottawa 3 x M7	Not tested	11
AR10-3-9	MM106 x M27	Susceptible 2012&13	9
AR120-242	M27 x MM106	Not tested	7
M116	MM106 x M27	Not tested	11

According to the protocol described in the methods section, material tested could be classified (Figure 11) with regards to its response to Fireblight by measuring the percentage of lesion developed in shoots. Following inoculation was compared with the susceptible control ('Gala Galaxy') and very low susceptibility control 'Enterprise'. The results from this test were received in July 2016. Figure 12 shows the evolution of the disease following inoculation and Figure 13 the final lesion levels in order of ascending susceptibility.

resistant	lesion length (%LL3)	< 5%	compared to %LL3 from 'Gala Galaxy'
very low	lesion length (%LL3)	5 - 25%	compared to %LL3 from 'Gala Galaxy'
low	lesion length (%LL3)	25 - 40%	compared to %LL3 from 'Gala Galaxy'
medium	lesion length (%LL3)	40 - 60%	compared to %LL3 from 'Gala Galaxy'
high	lesion length (%LL3)	60 - 100%	compared to %LL3 from 'Gala Galaxy'
very high	lesion length (%LL3)	> 100 %	compared to %LL3 from 'Gala Galaxy'

Figure 11. Classification of fire blight susceptibility in percentage compared to susceptible control 'Gala Galaxy' following inoculation at Agroscope (CH)

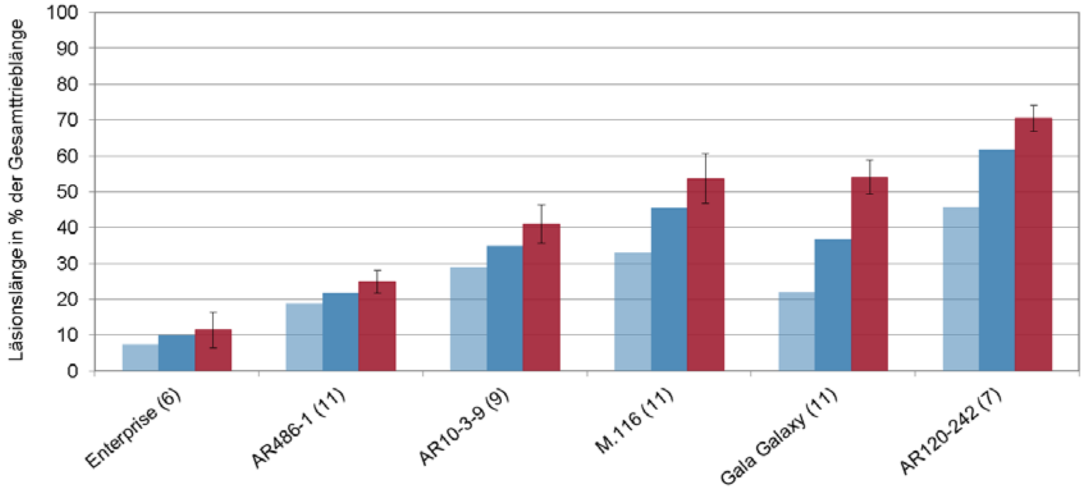


Figure 12. Lesion length as a percentage of total shoot length of eight apple genotypes measured 7, 14 and 21 days after inoculation with *Erwinia amylovora* (strain FAW610Rif at 109 cfu/ml[01])

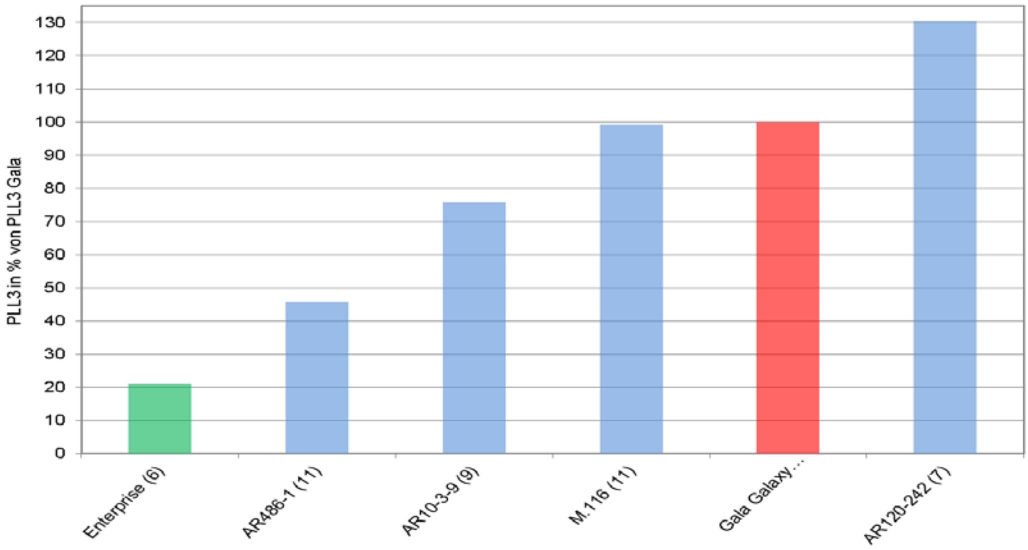


Figure 13. Percentage of lesion length 21 days after inoculation (PLL3) as a percentage of PLL3 in the susceptible control ('Gala Galaxy')

In this test, AR486-1 was found to show moderately low susceptibility (~45% compared to Gala) but higher that the values shown by AR295-6 in previous years. AR10-3-9 appear to be slightly less susceptible than Gala on this experiment whereas M.116 was found to be as susceptible and AR120-242 even more so. In Table 22, we summarised the results accumulated in four years of testing.

Table 22. Summary of fire blight (FB) resistance screening for EMR rootstock genotypes following repeated inoculation with *Erwinia amylovora* isolates ‘Ea782’, ‘Ea797’ and ‘Ea914’ in 2012 and ‘Ea797’, ‘Ea839’ and ‘Ea951’ in 2013 (both in Germany) and after single inoculation with ‘Ea FAW610 Rif’ in 2015 and 2016 (Agroscope, CH). Numbers of repetitions tested in each experiment are given in brackets

Genotype	% of necrosis (absolute disease)				PLL3 / PLL3 in Gala Galaxy (%)		Susceptibility score
	2012		2013				
	Range	Average (reps)	Range	Average (reps)	2015 (reps)	2016 (reps)	
AR10-2-5			55-100	87 (9)			High
AR10-3-9	47-100	78 (7)	60-86	66 (6)		76 (9)	High
AR120-242						130 (7)	Very high
AR295-6			3-25	10 (7)	15 (10)		Very low
AR440-1					70 (10)		High
AR486-1						45 (11)	Medium
AR680-2			65-100	82 (6)			High
AR809-3	17-100	74 (8)					High
AR835-11	4-95	53 (5)	21-84	42 (7)	27 (9)		Low
AR837-19			18-74	44 (10)			Low/Medium?
AR839-9	2-100	41 (8)	N/A	29 (1)	29 (9)		Low
AR852-3	47-100	80 (5)					High?
B24	21-100	73 (4)					Medium/High?
R104	53-100	77 (4)					High?
R59	58-100	84 (8)					High?
R80	19-100	68 (6)					Medium/High?
CG-935					2 (7)		Resistant
M.9 T337	19-100	69 (7)	16-100	48 (6)	102 (9)		Very high
M.116						99 (11)	High
Supporter 4			53-89	69 (5)			

Phytophthora cactorum

Propagation of hardwood cuttings was very successful in 2016. This allowed us include 20 genotypes (Table 23) in the *Phytophtora cactorum* inoculation. Plants were randomised within root trainers in the middle of April and moved into the glasshouse with temperature control (Figure 14). Four replicates were inoculated with 15 ml of 2x10^{-4} zoospores of two *P. cactorum* isolates (2/3 of ‘418’ and 1/3 of ‘295’) previously grown and re-isolated from apple. The experiment consisted for four inoculated replicates and one un-inoculated replicate as a control. Records on disease progression were taken weekly for four weeks. Symptoms in individual plants were fairly clear but not always consistent between replicates (Table 23). For this reason repeating of the experiment is planned in 2017.

Additionally, 250 seeds from an 'Evereste' x 'Geneva 30' cross were sown and used to verify the pathogenicity of the isolates. Four trays (xx - 50 young seedlings in each) were inoculated with xl of the same *P. cactorum* inoculum as above and an additional tray was kept un-inoculated for comparison (Figure 15a). Symptoms developed in a couple of weeks (Figure 15b) and, as expected (G.G.30 has been reported to be tolerant to *P. cactorum*) the family segregated for resistance to the disease; 106 resistant vs 32 susceptible which suggest 'Evereste' could also be a source for resistance. No seedlings were kept from this glasshouse screen but, in future, we could consider retaining resistant genotypes provided we could unsure that no disease is carried with them.

Table 23. Summary of *Phytophtora cactorum* resistance screening for EMR rootstock genotypes following repeated inoculation of '418' and '295' isolates. Orange colour indicates where symptoms were recorded; white cells were free of the disease evidence and final score in the last column of the table.

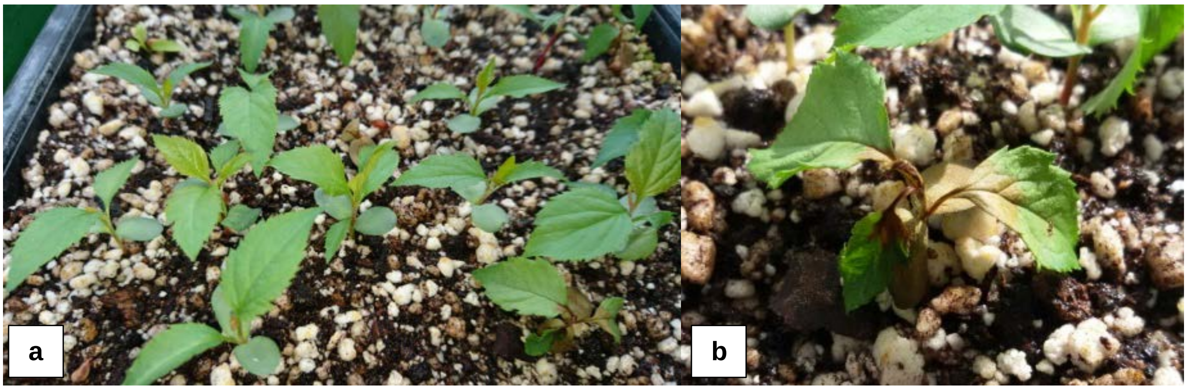
REP 1	REP 2	REP 3	REP 4	Score
AR10-3-9	AR10-3-9	AR10-3-9	AR10-3-9	Susceptible?
AR809-3	AR809-3	AR809-3	AR809-3	?
B24	B24	B24	B24	?
R104	R104	R104	R104	Resistant?
M432-217	M432-217	M432-217	M432-217	?
M432-250	M432-250	M432-250	M432-250	?
M482-11	M482-11	M482-11	M482-11	?
M482-13	M482-13	M482-13	M482-13	Resistant?
M482-153	M482-153	M482-153	M482-153	?
M482-158	M482-158	M482-158	M482-158	?
M482-175	M482-175	M482-175	M482-175	?
M482-54	M482-54	M482-54	M482-54	?
M482-65	M482-65	M482-65	M482-65	?
M545-145	M545-145	M545-145	M545-145	Susceptible
M546-110	M546-110	M546-110	M546-110	?
M547-1	M547-1	M547-1	M547-1	Resistant?
M547-41	M547-41	M547-41	M547-41	?
M547-72	M547-72	M547-72	M547-72	?
M547-8	M547-8	M547-8	M547-8	Resistant?
M549-94	M549-94	M549-94	M549-94	?

Figure 14. Randomized hardwood cuttings for *Phytophthora cactorum* inoculation. On right-hand side with red label was untreated replication

Figure 15. **(a)** Seedlings of 'Evereste' x 'C.G.30' cross segregating for symptoms of susceptibility to *Phytophthora cactorum* following inoculation. **b)** Close-up of symptoms (wilting and browning) on susceptible seedling

Apple Replant Disease (ARD)

The majority of work currently carried out at NIAB EMR is part of ARDERI project (HaPI II; BBSRC 2015-2018). The industry collaborators for this project are not the same as



those in the EMRC but some of its findings will support the characterisation of AR295-6 in replant scenarios following M.M.106 and M.9 orchards. This project looks at changes in soil microbiome (fungi, oomycetes, bacteria, and nematodes) in relation to the rootstock genotype present in the soil using metagenomics analysis over time. Relevant findings from this project will be communicated to AHDB as appropriate.

Additionally, we have recently established a small replant trial for our advance selections and commonly used germplasm. Between 9 and 12 rootstock liners of 22 rootstock genotypes (Table 24) were budded with a columnar scion in February 2015. The original plan was to set up tree replicates of each genotype in a) virgin soil, b) replant soil (untreated) and c) replant soil treated with chloropicrin in 2014. Unfortunately, grafting take and survival was not very good and for many of the EM selection there were not enough trees. Instead, we decided to save the virgin land (very rare) and set up a smaller treated vs untreated test with four replicates (Figure 16) with all the genotypes with 7 or more available trees.

In early 2017 record of height, diameter of the trunk at 10cm above graft union and shoots length were recorded. After all measurements shoots were tipped to encourage the growth as columnar scion is growing slower than traditional scions. Records will be taken again in winter 2017-18 and presented in the next annual report.

Table 24. Genotypes grafted with columnar scion in February 2015 for ARD trial plot and number of successful grafts available. In grey are indicated genotypes that have been planted for replant disease experiment

Source	Rootstock	Parentage	Reported ARD	Available
Dalicom	CG011	M. 26 x M. robusta 5	Susceptible	4
Dalicom	CG016	Ottawa 3 x M. floribunda	Partial tolerance	10
Dalicom	CG0202	M.27 x M. robusta 5	Tolerance	1
Dalicom	CG041	M.27 x M. robusta 5	Tolerance	2

Dalicom	CG0935	Ottawa 3 x M. robusta 5	Tolerance	4
IFO	AR10-2-5	M.M.106 x M.27	TBD	8
IFO	AR10-3-9	M.M.106 x M.27	TBD	4
IFO	AR440-1	M.25 x M.27	TBD	7
IFO	AR486-1	Ottawa 3 x M.7	TBD	4
IFO	AR628-2	Ottawa 3 x M.M.106	TBD	7
IFO	AR680-2	M.26 x M.7	TBD	7
IFO	AR835-11	M.I.793 x M.9a	TBD	8
IFO	AR837-19	M.3 x M.1	TBD	7
IFO	AR839-9	M.7 x M.27	TBD	5
IFO	AR86-1-20	M.M.106 x M.27	TBD	2
FP Matthews	M116	M.M.106 x M.27	Tolerance TBC	4
FP Matthews	M25	Northern Spy x M.2	Tolerance TBC	10
FP Matthews	M26	M.16 x M.9	Susceptible	9
FP Matthews	M27	M.13 x M.9	TBD	11
FP Matthews	M9	Unknown	Susceptible	9
FP Matthews	MM106	Northern Spy x M.1	Partial tolerance	13
IFO	AR295-6	M. robusta 5J x Ottawa 3	TBD	16

N ↑

Tree/Row	GE191 1	GE191 2	GE191 3	GE191 4	GE190 1	GE190 2	GE190 3	GE190 4
13	6	11	12	5	3	11	2	3
12	2	10	4	4	10	8	7	6
11	11	5	7	13	1	6	4	5
10	7	9	10	9	5	1	8	12
9	9	12	5	3	11	2	6	1
8	10	1	8	8	9	7	5	8
7	13	7	2	11	2	3	1	11
6	3	8	1	1	6	12	11	2
5	8	2	13	2	8	10	13	4
4	12	3	3	7	7	5	12	7
3	1	4	11	6	12	4	3	9
2	5	13	6	12	4	13	10	10
1	4	6	9	10	13	9	9	13

#	Rootstock	Parentage	Available
1	M.9	Unknown	9
2	M.25	Northern Spy x M.2	10
3	M.26	M.16 x M.9	9
4	M.27	M.13 x M.9	11
5	M.M.106	Northern Spy x M.1	13
6	CG-16	Ottawa 3 x *M. floribunda*	10
7	AR10-2-5	M.M.106 x M.27	8
8	AR295-6	*M. robusta 5* x Ottawa 3	16
9	AR440-1	M.25 x M.27	7
10	AR628-2	Ottawa 3 x M.M.106	7
11	AR680-2	M.26 x M.7	7
12	AR835-11	M.I.793 x M.9	8
13	AR837-19	M.3 x M.1	7

Figure 16. Experimental design for ARD test plot at East Malling. In blue field was treated with chloropicrin and in orange untreated field. Numbers of genotypes correlate into legend on the right with names

Woolly apple aphid (WAA)

Aphid populations in the field as well as in the glass house thrived during the reporting period. This allowed breeder to deselect a number of genotypes in the seedling populations during the field evaluation. It also made the GH screening more robust than in previous years with healthy colonies developing timely in susceptible genotypes. In total, 89 genotypes, including hard wood cuttings of various *Malus* species, rootstock cultivars and EM selections (Table 25), were inoculated from the end of July onwards. First score was performed two weeks post-inoculation and plants without colonies were re-inoculated up to three more times. Scoring continued throughout the autumn and results are presented in Table 25.

Table 25. Summary of results for woolly apple aphid screening at NIAB EMR between 2014 and 2016

Genotype	Parentage	2014 Reps	2014 Score	2014 Range	Score 2014	2015 Reps	2015 Score	2015 Range	Score 2015	2016 Reps	2016 Score	2016 Range	Score 2016
M793	Northern Spy xM2									5	0.00	0	Resistant
Voinesti	?									5	0.25	0-1	Resistant
AR10-3-9	M.27 x M.M.106	8	1.4	0-3	Susceptible?	4	1.00	0-2	Fairly resistant	5	2.40	1-3	Susceptible
AR628-2	Ottawa 3 x M.M.106	9	1.4	0-3	Susceptible					7	0.14	0-1	Resistant
AR682-6	M.26 x MI.793	6	0.5	0-1	Fairly resistant					5	0.33	0-2	Resistant
AR809-3	R.80 x M.26	4	1.5	0-2	Fairly resistant?	4	0.60	0-2	Fairly resistant	5	3.00	3	Susceptible
AR839-9	M.7 x M.27	3	0.7	0-1	Fairly resistant					5	0.00	0	Resistant
B24	AR10-2-5 x AR86-1-22	2		0-2?	?	1	1.00	1	Fairly resistant	3	0.33	0-1	Resistant
R59										5	3.00	3	Susceptible
R104	AR134-31 x AR86-1-22	1	0.0	0	Resistant?					5	2.80	2-3	Susceptible
M306-6	AR86-1-20 x M.20	4	1.0	0-3	?	4	0.43	0-1	Fairly resistant	4	1.67	0-3	Mod susceptible
M306-20	AR86-1-20 x M.20	4	1.0	0-2	Mod susceptible					3	2.33	1-3	Susceptible
M345-32	MM106 x Totem									5	3.00	3	Susceptible
M360-9	AR86-1-20 x M.9									4	2.33	1-3	Susceptible
M360-21	AR86-1-20 x M.9									5	2.20	0-3	Susceptible
M360-84	AR86-1-20 x M.9									5	2.60	1-3	Susceptible
M360-191	AR86-1-20 x M.9									4	2.50	2-3	Susceptible
M430-249	Midew Immune Sdlg x M.27									3	0.33	0-1	Resistant
M432-203	M.27 x M.116									5	1.00	1	Fairly resistant
M432-217	M.27 x M.116	4	0.8	0-1	?	5	0.95	0-1	Fairly resistant	5	2.80	2-3	Susceptible
M432-247	M.27 x M.116									4	2.25	1-3	Susceptible
M432-250	M.27 x M.116	4	2.0	1-3	Susceptible					5	3.00	3	Susceptible
M480-3	M.9 x M.116									5	1.00	1	Fairly resistant
M481-10	M.9 x Geneva 202									5	3.00	2-3	Susceptible
M482-11	M.9 x M.116/G.202	4	1.0	1	?	3	0.67	0-1	Fairly resistant	5	3.00	3	Susceptible
M482-13	M.9 x M.116/G.202	4	1.0	2	?	4	2.33	1-3	Susceptible	5	3.00	3	Susceptible
M482-42	M.9 x M.116/G.202									5	3.00	3	Susceptible
M482-44	M.9 x M.116/G.202									5	3.00	3	Susceptible
M482-49	M.9 x M.116/G.202	4	1.0	1	?	4	2.17	0-3	Susceptible	5	3.00	5	Susceptible
M482-54	M.9 x M.116/G.202	4	1.3	1-2	?	3	1.44	1-2	Fairly resistant	5	2.60	5	Susceptible
M482-65	M.9 x M.116/G.202									5	3.00	3	Susceptible
M482-76	M.9 x M.116/G.202									5	3.00	3	Susceptible
M482-84	M.9 x M.116/G.202									5	3.00	3	Susceptible
M482-133	M.9 x M.116/G.202									3	1.67	1-2	Mod susceptible
M482-153	M.9 x M.116/G.202					5	0.33	0-1	Resistant	5	3.00	3	Susceptible
M482-158	M.9 x M.116/G.202					5	0.87	0-2	Fairly resistant	6	2.50	0-3	Susceptible
M482-175	M.9 x M.116/G.202	4	2.0	1-3	Susceptible?	3	1.78	1-3	Susceptible	5	3.00	3	Susceptible
M508-1	M.13 x JM7									5	0.80	0-1	Fairly resistant
M508-22	M.13 x JM7									3	2.67	2-3	Susceptible
M508-41	M.13 x JM7	4	2.8	1-3	Susceptible					5	3.00	3	Susceptible
M508-49	M.13 x JM7									5	1.40	0-2	Fairly resistant
M509-22										5	1.20	1-2	Fairly resistant
M545-57	M.9 x Geneva 202									4	3.00	3	Susceptible
M545-145	M.9 x Geneva 202									5	3.00	3	Susceptible
M546-9	M.9 x JM7	4	0.8	0-1	Resistant?					5	3.00	3	Susceptible
M546-22	M.9 x JM7	4	0.3	0-1	Resistant					5	0.80	0-1	Fairly resistant
M546-110	M.9 x JM7	4	0.5	0-1	Resistant?					5	1.00	1	Fairly resistant
M546-125	M.9 x JM7	4	1.0	0-2	Susceptible?	4	2.00	1-3	Susceptible	5	3.00	3	Susceptible
M547-1	M.9 x M. floribunda 821	4	1.8	1-3	Susceptible					5	3.00	3	Susceptible
M547-8	M.9 x M. floribunda 821									5	0.60	0-1	Fairly resistant
M547-41	M.9 x M. floribunda 821									5	0.00	0	Resistant
M547-72	M.9 x M. floribunda 821									5	3.00	3	Susceptible
M548-2	M.13 x Geneva 202									5	3.00	3	Susceptible
M549-59	M13 x JM7									5	1.00	1	Fairly resistant
M549-83	M13 x JM7									5	0.00	0	Resistant
M549-94	M13 x JM7									5	0.00	0	Resistant
M549-122	M13 x JM7									4	0.00	0	Resistant
M549-146	M13 x JM7									7	0.43	0-1	Resistant
M550-12	AR86-1-20 x M.9 EMLA									4	0.50	0-1	Fairly resistant
M550-25	AR86-1-20 x M.9 EMLA									4	2.50	2-3	Susceptible
M550-40	AR86-1-20 x M.9 EMLA									4	1.75	1-2	Mod susceptible
M550-41	AR86-1-20 x M.9 EMLA									4	1.00	1	Fairly resistant
M550-67	AR86-1-20 x M.9 EMLA									4	3.00	3	Susceptible
M551-8	M.16 x M.9a									4	3.00	3	Susceptible
M551-50	M.16 x M.9a									4	3.00	3	Susceptible
M552-43	White Angel x M.9 EMLA									4	3.00	3	Susceptible
M552-89	White Angel x M.9 EMLA									4	3.00	3	Susceptible
M552-92	White Angel x M.9 EMLA									4	3.00	3	Susceptible
M552-108	White Angel x M.9 EMLA									4	3.00	3	Susceptible
M116	M.M.106 x M.27	12	0.3	0-1	Resistant	4	0.42	0-1	Resistant	1	0.00	0	Resistant
M27	M.13 x M.9	8	1.8	0-3	Susceptible					3	2.67	2-3	Susceptible
Evereste										1	3.00	3	Susceptible
Budagovsky										2	2.00	1-3	Susceptible
M. robusta 5a										2	0.00	0	Resistant
M. zumi										2	0.50	0-1	Fairly resistant
M. orthocarpa										2	2.00	1-3	Susceptible
M. glaucesscens										4	0.25	0-1	Resistant
M. haliana										2	0.00	0	Resistant
M. stikoaensis										2	0.50	0-1	Fairly resistant
M. platycarpa EMLA										2	0.50	0-1	Fairly resistant
Mac 9										2	1.00	1	Fairly resistant
M. tchonoskii										2	0.00	0	Resistant
M. toringo M.										1	3.00	3	Susceptible
Geneva 202										2	3.00	3	Susceptible
MIS										2	0.00	0	Resistant
M. baccata illipsoidess										2	0.00	0	Resistant
M.floribunda J										1	0.00	0	Resistant
MM 106a										2	0.00	0	Resistant
M. robusta persicif										1	0.00	0	Resistant

Knowledge and Technology Transfer

EMRC management committee meeting – Ferrara, September 2016

EMRC management committee meeting – East Malling, February 2017