Project title:	Evaluation and development of new rootstocks for apples – on-going work on existing plantings
Project number:	TF 172a
Project leader:	Gary Saunders, East Malling Research
Report:	Annual report, April 2013
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Location of project:	East Malling Research, New Road, East Malling, Kent. ME19 6BJ
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Date project commenced:	1 May 2012
Date project completed (or expected completion date):	30 April 2016

DISCLAIMER

AUTHENTICATION

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

Gary M. Saunders
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Signature ..... Date .....

Report authorised by:

Professor Peter J. Gregory
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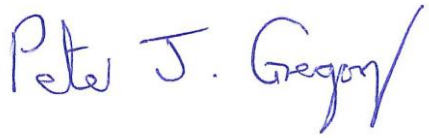

29 April 2013

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GROWER SUMMARY

Headline

- Two selections from the East Malling Rootstock Club breeding programme were assessed but neither AR801-11 nor AR680-2 were an improvement on the M9 rootstock for Queen Cox grown under conventional management.

Background and expected deliverables

A review of HDC-funded rootstock research projects (Project TF 158) acknowledged that there was a strong need for new or improved rootstocks for apples, pears, plums and cherries that are dwarfing, precocious, high yielding and offer some measure of drought tolerance. The report recognised that whilst rootstocks are a vital part of current growing systems, those currently used in commercial production have been grown for decades and have some limitations. Breeding programmes in the UK and abroad have generated a number of promising rootstocks in recent years, which are becoming increasingly available to growers. The report recommended that UK trialling of promising UK and overseas material should continue and that technology transfer should be improved. This work was then undertaken in HDC project TF 172 (*Evaluation and development of new rootstocks for apples, pears, cherries and plums*).

This new project is a continuation of HDC project TF 172 but includes only apple rootstocks. The main aim of the project is to acquire, evaluate (in UK growing conditions) and develop new apple and pear rootstocks, produced by breeding programmes both at EMR and abroad. This project provides continuity of the trialling of fruit tree rootstocks at EMR. It will look for rootstocks of intermediate vigour between M27 and M9 and a replacement for M26 in apple, with continued evaluation of existing plots that were identified as having new rootstocks of potential merit.

Summary of the project and main conclusions

This new project is a continuation of the evaluation of trees in some of the existing plots from HDC project TF 172. The rootstocks included are those with commercial potential rather than selections that were identified as ‘also ran’.

Three existing plots containing the following rootstocks are being assessed:

- Plot CE190: Rootstocks AR801-11 and AR680-2 - planted in May 2004 with Queen Cox scion and compared to M9.
- Plot EE207: Rootstocks AR852-3, AR839-9, B24, R59 and R104 – planted in March 2010 with Braeburn and Gala scions and compared to M26, M9 and M27 standards.
- Plot VF224: Rootstocks AR10-3-9, AR809-3, AR835-11 and R80 – planted in March 2010 with Red Falstaff scion and compared with MM106 and M116 standards.

Plot CE190

Yields (fruit weight per tree) have been recorded during the previous trial and again in 2012. Yields from both AR801-11 and AR680-2 were significantly lower than that of the M9 rootstock. AR801-11 had a significantly smaller crown volume than M9, but there was no significant difference in crown volume between AR680-2 and M9. There were also no significant differences between any of the rootstocks in tree height, mean individual fruit weight and yield efficiency. This indicates that neither of the rootstocks AR801-11 or AR680-2, offer an improvement on the M9 rootstock for Queen Cox grown under conventional management.

Plot EE207

Although there were significant differences in each of the yield categories in 2012, this plot is a recent planting and fruit numbers have not yet reached levels of a commercial significance. An average of only 13 Braeburn fruit per tree or 22 Gala fruit per tree were picked from the most productive rootstock, whereas in a more mature commercial planting anything up to 350 fruit per tree could be achieved. There were significant differences in tree growth, with AR852-3 and R104 having the greatest tree height and crown volume for Braeburn and B24 and M26 for Gala. It is still too early to draw any real conclusions from this plot of Braeburn and Gala grown under conventional management.

Plot VF224

Like Plot EE 207, this is a recently planted plot and as yet there are no significant differences in any of the yield assessments. At present the selection AR809-3 is significantly less vigorous than any of the other selections but the plot is still establishing. It is still too early to draw any real conclusions from this plot of Red Falstaff grown under organic management.

Conclusions

- Neither AR801-11 nor AR680-2 was an improvement on the M9 rootstock for Queen Cox grown under conventional management.
- It is too early to determine if any of the selections in Plots EE207 or VF224 are suitable replacement rootstocks.

Financial benefits

Selection and release of improved rootstocks to the industry will be of financial benefit as the introduction of new rootstocks with increased precocity and yield with fewer requirements for chemical or mechanical growth control and lower pruning costs will have a huge impact on the profitability of UK orchards.

Action points for growers

There are no action points at present.

SCIENCE SECTION

Introduction

A review of HDC-funded rootstock research projects (project TF 158) acknowledged that there was a strong need for new or improved rootstocks for apples, pears, plums and cherries that are dwarfing, precocious, high yielding and offer some measure of drought tolerance. The report recognised that rootstocks are a vital part of the currently used growing systems for tree fruits but that those currently used in tree fruit production have been grown for decades and all have some limitations. Breeding programmes in the UK and abroad have generated a number of promising rootstocks in recent years, which are becoming increasingly available to growers. The report recommended that UK trialling of promising UK and overseas material should continue and that technology transfer should be improved. This work was then undertaken in HDC project TF 172 - Evaluation and development of new rootstocks for apples, pears, cherries and plums.

This new project is a continuation of the evaluation of trees in some of the existing plots from HDC project TF 172. These plots were those identified as those containing rootstocks with potential as commercial rootstocks rather than selections that were identified as 'also ran'. The main aim of the project was to acquire, evaluate and develop in UK growing conditions, new apple, pear, cherry and plum rootstocks produced by breeding programmes both at EMR and abroad. In this continuation of the work, only selections of apple rootstocks that were deemed to have potential, related to the following objectives were evaluated:

- To select and develop apple rootstocks with intermediate vigour between M27 and M9, which perform well in the nursery and which produce precocious and consistently abundant yields of high quality fruits of the marketable size grades
- To select and develop a replacement rootstock in the M26 vigour category, which does not suffer from burr knotting, poor calcium uptake or physiological disorders in the scion fruit. This rootstock should also induce precocious and abundant yields of high quality fruits
- To select and develop dwarfing rootstocks for apple which exhibit improved resistance to drought, weed competition, replant disease and soil borne diseases (e.g. collar/crown rot)

Selection and release of improved rootstocks to the industry will be of benefit as the introduction of new rootstocks, with increased precocity and yield and with fewer requirements for chemical or mechanical growth control and pruning, will have a huge impact on the profitability of UK orchards.

Materials and methods

The trial was conducted at East Malling Research, New Road, East Malling, Kent. Three plots were evaluated:

- CE190 under conventional management
- EE207 under conventional management
- VF224 under organic management.

Under conventional management tree rows were maintained weed free using conventional herbicides (a rotary hoe was used for organic management) and the alleys between the rows were grassed down and maintained by frequent mowing. No supplementary irrigation was supplied to the trees. Minimal pruning was undertaken in the first few years following planting; the trees were, however, headed when necessary to encourage the production of lateral branches, but no branch tipping was undertaken. Where appropriate, very upright branches were tied down towards the horizontal and a modified form of 'long spur pruning' employed. No chemical growth regulators or root pruning techniques have been used to supplement growth control in any of the trials reported on.

AR801-11 and AR680-2 rootstocks were planted in May 2004 in plot CE190 with Queen Cox scion and compared to M9. In plot EE207, planted in March 2010 with Braeburn and Gala scion varieties, the rootstocks AR852-3, AR839-9, B24, R59 and R104 were assessed with M26, M9 and M27 standards. The organic plot VF224, planted in March 2010, contained AR10-3-9, AR809-3, AR835-11, R80, MM106 and M116 rootstocks with Red Falstaff as the scion variety.

Each orchard was assessed in terms of:

- tree growth: height and spread of the tree
- cropping: total yields, yield of Class I >65mm (cumulative yields and yield efficiencies were calculated)
- miscellaneous: notes of tree health, graft compatibility and anchorage were made where appropriate

Results

CE190 - under conventional management

In this plot two East Malling rootstock club selections were compared to M9 under conventional management with Queen Cox as the scion variety. In 2012 the total yield in terms of weight per tree and Class I yield in terms of weight and number per tree was significantly greater for M9 than either of the selections from the breeding programme (Table1). Cumulative yield, both total fruit and Class I fruit weight, over the period of 2004-2012 was significantly different for M9 compared to the other two rootstocks, with M9 having a greater cumulative yield than AR680-2 and AR801-11 (Table 2). Table 3 shows that there were no significant differences in terms of mean individual fruit weight, yield efficiency or tree height but that there was a significant difference in crown volume with M9 having a greater crown volume than AR801-11, but that neither of these selections were significantly different to AR680-2.

Table 1. Yield of Queen Cox trees (Plot CE190, 2012)

	Yield 2012 (kg/tree)	**Yield 2012 (number/tree)**	**Yield Class I >65mm 2012 (kg/tree)**	**Yield Class I >65mm 2012 (number/tree)**
AR801-11	5.47	58.87	2.49	18.25
AR680-2	4.04	37.50	1.97	12.37
M9	13.44	134.00	6.87	50.12
SED (27 df)	3.23	36.77	1.72	12.80
Rootstock effect	*	ns	*	*

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

Table 2. Cumulative yield of Queen Cox trees (Plot CE190, 2004-2012)

	Cumulative yield 2004-2012 (kg/tree)	**Cumulative yield Class I >65mm 2004-2012 (kg/tree)**
AR801-11	37.71	11.97
AR680-2	43.76	18.98
M9	64.67	30.61
SED (27 df)	7.39	4.86
Rootstock effect	**	**

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

Table 3. Growth and crop characteristics of Queen Cox trees (Plot CE190, 2012)

	Tree height (dm)	**Crown volume (m^3)**	**Mean individual fruit weight (kg)**	**Yield efficiency (kg/m^3)**
AR801-11	20.74	7.89	0.11	5.31
AR680-2	22.00	10.55	0.17	5.05
M9	23.75	13.05	0.09	4.93
SED (27 df)	1.53	1.998	0.03	0.90
Rootstock effect	ns	*	ns	ns

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

EE207 - under conventional management

In this recently planted plot, two East Malling Rootstock Club selections and three externally sourced rootstocks were compared to M9, M26 and M27 under conventional management with Braeburn and Gala as scion varieties.

Braeburn

Total yield and yield of class I fruit, both in terms of weight and numbers of fruit, were significantly higher for AR852-3, M27 and R59 than for AR839-9, B52 and M26 (Table 4). Tree height was greatest for AR852-3 and R104 followed by AR839-9, B24 and M26 which in turn were significantly greater than M27, M9 and R59 (Table 5). Crown volume was significantly greater for AR852-3, B24 and R104 than for M27 and R59 (Table 5). There were no significant differences in mean individual fruit weight between B24 and AR839-9 but mean individual fruit weight was significantly greater for B24 than any of the other rootstocks (Table 5).

Table 4. Yield of Braeburn trees (Plot EE207, 2012)

	Yield 2012 (kg/tree)	**Yield 2012 (number/tree)**	**Yield Class I >65mm 2012 (kg/tree)**	**Yield Class I >65mm 2012 (number/tree)**
AR852-3	2.50	11.28	1.92	9.17
AR839-9	1.16	3.23	0.83	2.90
B24	1.03	3.11	0.48	1.06
M26	1.19	5.01	0.69	2.30
M27	2.80	12.25	2.06	9.25
M9	1.61	7.00	0.98	4.37
R104	2.18	9.60	1.43	6.62
R59	2.42	11.93	1.69	7.60
SED (45 df)	0.48	2.62	0.38	2.03
Rootstock effect	***	***	***	***

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

Table 5. Growth and crop characteristics of Braeburn trees (Plot EE207, 2012)

	Tree height (dm)	**Crown volume (m^3)**	**Mean individual fruit weight (kg)**	**Yield efficiency (kg/m^3)**
AR852-3	23.08	2.86	0.28	1.37
AR839-9	20.25	2.32	0.41	0.35
B24	19.94	2.52	0.47	0.82
M26	21.09	2.33	0.27	0.50
M27	16.75	1.25	0.25	3.08
M9	16.12	2.06	0.31	2.23
R104	23.37	2.88	0.27	0.99
R59	17.28	1.32	0.21	2.25
SED (45 df)	1.56	0.54	0.08	1.03
Rootstock effect	***	*	*	ns

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

Gala

The greatest yield in 2012 in terms of fruit weight and number was for M26, and this was significantly higher than AR852-3, B24 and R104 (Table 6). The greatest class I yield in 2012 in terms of fruit weight and number was for M26 and this was significantly higher than AR852-3, AR839-9, B24 and R104 (Table 6). Tree height was greatest for B24, which was significantly greater than AR852-3, AR839-9, M27, M9 and R59. M27 had the smallest tree height and this was significantly smaller than all of the other selections (Table 7). There was a range of crown volumes, with the greatest being B24 and the smallest M27. The crown volume of B24 was greater than AR852-3, M27, R104 and R59 and M27 was smaller than AR839-9, B24, M26, M9 and R104 (Table 7). There were no significant differences in mean individual fruit weight but M27 had a significantly greater yield efficiency than all selections other than R59 (Table 7).

Table 6. Yield of Gala trees (Plot EE207, 2012)

	Yield 2012 (kg/tree)	**Yield 2012 (number/tree)**	**Yield Class I >65mm 2012 (kg/tree)**	**Yield Class I >65mm 2012 (number/tree)**
AR852-3	2.38	10.60	1.77	8.97
AR839-9	3.19	15.05	2.07	9.98
B24	1.74	8.80	1.13	6.17
M26	4.25	21.87	3.45	19.61
M27	3.39	18.11	2.47	14.09
M9	3.67	20.17	2.58	14.55
R104	2.26	10.67	1.47	7.44
R59	3.75	19.38	2.99	16.55
SED (44 df)	0.65	4.16	0.58	3.70
Rootstock effect	*	*	**	*

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

Table 7. Growth and crop characteristics of Gala trees (Plot EE207, 2012)

	Tree height (dm)	**Crown volume (m^3)**	**Mean individual fruit weight (kg)**	**Yield efficiency (kg/m^3)**
AR852-3	20.28	2.19	0.28	1.21
AR839-9	20.54	3.32	0.23	0.78
B24	24.88	4.45	0.33	0.71
M26	23.49	4.08	0.20	0.82
M27	16.89	1.27	0.20	4.35
M9	21.69	3.32	0.18	1.20
R104	22.92	2.76	0.33	1.20
R59	19.94	1.92	0.21	2.12
SED (44 df)	1.44	0.56	0.05	1.25
Rootstock effect	***	***	ns	*

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

VF224 - under organic management

In this recently planted plot, three East Malling rootstock club selections and one externally sourced rootstock were compared to M116 and MM106 under organic management with Red Falstaff as the scion variety. There were no significant differences in terms of yield in 2012 (Table 8) or in mean individual fruit weight or yield efficiency (Table 9). Tree height and crown volume was significantly smaller for AR809-3 than for all of the other selections (Table 9).

Table 8. Yield of Red Falstaff trees (Plot VF224, 2012)

	Yield 2012 (kg/tree)	**Yield 2012 (number/tree)**	**Yield Class I >65mm 2012 (kg/tree)**	**Yield Class I >65mm 2012 (number/tree)**
AR10-3-9	0.49	3.62	0.26	1.75
AR809-3	0.35	3.00	0.13	1.00
AR835-11	0.48	4.00	0.36	2.87
M116	0.44	3.75	0.18	1.25
MM106	0.40	3.37	0.21	1.50
R80	0.70	6.25	0.27	2.00
SED (27 df)	0.20	1.76	0.16	1.22
Rootstock effect	ns	ns	ns	ns

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

Table 9. Growth and crop characteristics of Red Falstaff trees (Plot VF224, 2012)

	Tree height (dm)	Crown volume (m^3)	Mean individual fruit weight (kg)	Yield efficiency (kg/m^3)
AR10-3-9	18.00	0.59	0.16	4.93
AR809-3	12.00	0.11	0.12	5.15
AR835-11	18.00	0.84	0.11	5.99
M116	18.25	0.52	0.14	5.31
MM106	17.62	0.80	0.12	5.05
R80	16.50	0.92	0.11	5.29
SED (27 df)	1.51	0.22	0.02	0.90
Rootstock effect	**	*	ns	ns

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

Discussion

CE190 - under conventional management

In 2012 and cumulative between 2004-2012, the yield in terms of fruit weight per tree of the two selections AR801-11 and AR680-2 were significantly lower than that of the M9 rootstock. AR801-11 had a significantly smaller crown volume than M9, but there was no significant difference in crown volume between AR680-2 and M9. There were also no significant differences between any of the rootstocks for tree height, mean individual fruit weight and yield efficiency. This shows that neither of the rootstocks AR801-11 or AR680-2 are an improvement on the M9 rootstock for Queen Cox grown under conventional management.

EE207 - under conventional management

Although there were significant differences in each of the yield categories, this is a recently planted plot with fruit numbers not yet of any commercial significance. An average of only 13 Braeburn fruit per tree or 22 Gala fruit per tree were picked from the most productive rootstock whereas in a more mature commercial planting anything up to 350 fruit per tree could be achieved. There were significant differences in tree growth with AR852-3 and R104 having the greatest tree height and crown volume for Braeburn and B24 and M26 for Gala. It is still too early to draw any real conclusions from this plot of Braeburn and Gala grown under conventional management.

VF224 - under organic management

Again, this is a recently planted plot and as yet there are no significant differences in any of the yield assessments. At present the selection AR809-3 is significantly less vigorous than any of the other selections but the plot is still establishing. It is again still too early to draw any real conclusions from this plot of Red Falstaff grown under organic management.

Conclusions

- Neither AR801-11 nor AR680-2 were an improvement on the M9 rootstock for Queen Cox grown under conventional management
- It is too early to determine if any of the selections in plots EE207 (conventional management) and VF224 (organic management) are suitable replacement rootstocks

Knowledge and Technology Transfer

An *HDC News* article is planned for June 2013.