Project title:	Resources for future breeding of apple utilising genome-wide selection
Project number:	TF 211
Project leader:	Richard Harrison, East Malling Research
Report:	Annual, March 2014
Previous report:	None
Key staff:	Richard Harrison
Location of project:	East Malling Research
Industry Representative:	Jim Quinlan, EMT
Date project commenced:	1 April 2013
Date project completed (or expected completion date):	31 March 2015

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AUTHENTICATION

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

Richard Harrison

Group Leader

EMR

Signature ..... Date .....31/3/2014.....

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CONTENTS

GROWER SUMMARY

Headline

Developing cultivars with both disease resistance and high fruit quality requires extensive breeding.

Background and expected deliverables

The UK has lacked a cultivar development programme for many years. Many new cultivars with excellent fruit quality and storage attributes are now available. However, these are increasingly problematic to grow, primarily due to high susceptibility to fungal canker and high levels of susceptibility to apple scab, mildew and aphids. As a pilot study, a small amount of funding was made available by the HDC Tree Fruit Panel to carry out some capacity building work to identify methods of breeding that offer the ability to simultaneously select for fruit quality attributes and disease resistance.

Growers need both new rootstocks and new scion cultivars that are future-proofed against more variable climatic conditions. The beginnings of such a programme require experimental plantings in order to leverage additional funding from government (e.g. BBSRC and EU projects). As a result, a modest investment at this stage by HDC has the potential to deliver far more basic research in future years and hence contribute to growers by the delivery of new knowledge and later new cultivars that can be grown across the world.

The data generated in this study will feed into and complement an existing project currently funded by the HDC (TF 182), in the form of The East Malling Rootstock Club (EMRC). This will facilitate a quicker route to the release of new commercial rootstocks and hence subsequent financial benefit to the industry.

Summary of the project and main conclusions

A preliminary study of all reported sources of pest and disease resistance traits that are publically available revealed that there are multiple unexploited resistances to fungal canker, rosy apple aphid, powdery mildew and apple scab that are completely absent from modern commercial cultivars (assessed by pedigree-based analysis). Work is currently underway to propagate these sources of resistance, along with cultivars displaying exceptional fruit quality and storage attributes, to provide a set of mother trees, from which controlled pollination can be carried out. The establishment of material segregating for P&D, canopy architecture (suitable for modern production), yield and fruit quality, suitable for a genome-wide selection (GWS) population (allowing simultaneous selection of these traits) is likely to take in the order of 6-8 years.

Financial benefits

A brief summary of financial benefits will be provided in the final report.

Action points for growers

- Consider new cultivar development programmes for genome-wide selection (GWS).

SCIENCE SECTION

Introduction

Genomic selection has been applied for the last 10 or so years in the animal breeding world, by large multinational companies. Horticultural breeding has lagged far behind due to the smaller nature of breeding programmes, the lack of genomic information and the prohibitive cost of DNA sequencing technologies. These latter problems are quickly disappearing, allowing smaller breeding programmes to take advantage of genome-wide selection (GWS) approaches. Currently GWS is not deployed in any UK horticultural crop breeding programmes, though it is most useful in crops with a long breeding cycle, such as apple, cherry and pear. GWS has the potential to revolutionise breeding and allow the development of varieties tailored to future growing conditions for a modest cost. GWS improves the accuracy of breeding and reduces the time taken for variety development by at least 5 years.

It is important that UK researchers re-enter collaborative research exercises to underpin modern breeding. EMR has the opportunity to engage in such activities, providing suitable field populations are available for study. Collaboration and engagement with European partners is beneficial both for EMR and for the HDC as it will offer large returns on a modest initial investment.

Materials and methods

Scion wood was collected during the dormant season of 2013-14 and bench grafted onto M9 rootstocks for field planting in late 2014.

Results

Milestone 1- 31 October 2013- Germplasm Identification

This milestone has been completed. A full list of germplasm is attached in appendix 1. A list of traits of interest is under preparation for the final report.

Milestone 2- 1 February 2014- Grafting completed

This milestone has been completed.

Milestone 3- 31 November 2014- Planting of genomic selection populations

This milestone is yet to be completed.

Discussion and conclusions

At this stage there is nothing to discuss or conclude but a discussion and conclusions will be included in the final report.

Knowledge and technology transfer

None to date apart from mention in the Tree Fruit Review outlining the project.

Appendices – Appendix 1 - Full list of germplasm

Mother tree	Location	Grafted	Comments
Yellow Bellflower	BR	Y	
Woolbrook Russett	BR	Y	
Wolf River	BR	Y	
Wagener	BR	Y	
T31/12	**AS**	Y	
Sturmer pippin	BR	Y	
Splendour	BR	Y	
Saturn	BR	Y	
Santana	BR	Y	
Rubens	BR	Y	
Royal Jubilee	BR	Y	
Rome Beauty	BR	Y	
Rev W Wilkes	BR	Y	
Rall's Janet	BR	Y	
Priscilla	BR	Y	
Pitmaston pineapple	BR	Y	
McIntosh	BR	Y/N	
M. prattii	*GB*	Y	
M. halliana	*GB*	Y	
Lady Williams	BR	Y	
King of the Pippins	BR	Y	
Kidd's Orange Red	BR	Y	
Kanzi	BR	Y	2(S)
Jonathan (mutation Jonared)	BR	Y	
Jonathan	BR	Y	
Jersey Mac	BR	Y	
James Grieve	BR	Y	
Ingrid Marie	BR	Y	
Indo	BR	Y	
Idared	BR	Y	
Granny Smith	BR	Y	
Golden Delicious	BR	Y	
Gloster 69	BR	Y	
Gladstone	BR	Y	
Gascoyne's scarlet	BR	Y	
Gala	BR	Y	
G1-27	**AS**	Y	
Fuji	BR	Y	
Florina	BR	Y	
Filippa	BR	Y	
Fiesta	BR	Y	
Falstaff	BR	Y	
ex Rocks	*GB*	Y	
Elstar	BR	Y	

Egremont Russet	BR	Y	
Mother tree	**Location**	**Grafted**	**Comments**
Early Victoria	BR	Y	
E93-8	**AS**	Y	
E93-79	**AS**	Y	
E93-6	**AS**	Y	
E93-51	**AS**	Y	
E93-45	**AS**	Y	
E93-42	**AS**	Y	
E83-4	**AS**	Y	
E753-22	**AS**	Y	
E721-1	**AS**	Y	
E714-1	**AS**	Y	
E699-4	**AS**	Y	
E617-10	**AS**	Y	
E616-89	**AS**	Y	
E616-196	**AS**	Y	
E611-21	**AS**	Y	
E604-5	**AS**	Y	
E603-11	**AS**	Y	
E558-1	*GB*	Y	3 (s)
E55-55	**AS**	Y	
E54-77	**AS**	Y	
E506-336	**AS**	Y	
E500-47	**AS**	Y	
E481-45	**AS**	Y	
E447-79	**AS**	Y	
E447-62	**AS**	Y	
E409-7	**AS**	Y	
E403-21	**AS**	Y	
E403-19	**AS**	Y	
E402-16	**AS**	Y	
E394-5	**AS**	Y	
E388-12	**AS**	Y	
E303-47	**AS**	Y	
E303-20	**AS**	Y	
E303-15	**AS**	Y	
E277-55	**AS**	Y	
E273-55	**AS**	Y	
E273-49	**AS**	Y	
E273-35	**AS**	Y	
E256-24	**AS**	Y	
E250-3	**AS**	Y	
E249-2 (E249-5)	**AS**	Y	
E248-2	**AS**	Y	
E244-4	**AS**	Y	
E244-30	**AS**	Y	

E244-28	**AS**	Y	
E243-93	**AS**	Y	
Mother tree	**Location**	**Grafted**	**Comments**
E241-17	**AS**	Y	
E239-104	**AS**	Y	
E234-23	**AS**	Y	
E232-2	**AS**	Y	
E209-69	**AS**	Y	
E209-67	**AS**	Y	
E209-129	**AS**	Y	
E207-47	**AS**	Y	
E207-187	**AS**	Y	
E207-140	**AS**	Y	
E202-6	**AS**	Y	
E201-68	**AS**	Y	
E19-13B	**AS**	Y	
E19-13A	**AS**	Y	
Duke of Devonshire	**BR**	Y	
Discovery	**BR**	Y	
Delicious	**BR**	Y	
D'Arcy Spice	**BR**	Y	
Cravert Rouge	**BR**	Y	
Cox	**BR**	Y	
Court-pendu plat	**BR**	Y	
Canker res sdlg 2	**GB**	Y	
Brownlees Russet	**BR**	Y	
Bloody Ploughman	**BR**	Y	
Beauty of bath	**BR**	Y	
Ashmeads Kernal	**BR**	Y	Only 2 (s)
Aroma	**BR**	Y	
Allington Pippin	**BR**	Y	
Adam's Pearmain	**BR**	Y	
A886-19	**AS**	Y	
A886-17	**AS**	Y	
A787-9	**AS**	Y	
A746-18	**AS**	Y	
A469-4	**GB**	Y	
A2041	**GB**	Y	
A2039 (Red melba)	**GB**	Y	
A1993	**GB**	Y	
A1990	**GB**	Y	2 (s)
A1899	**GB**	N	
A1899	**GB**	Duplicate	
A1898	**GB**	Y	
A1891	**GB**	Y	
A1890	**GB**	N	
A1889	**GB**	Y	3 (s)

A1731	**GB**	Y	3 (s)
A142-1	**GB**	Y	
A140-10	**GB**	Y	
Mother tree	**Location**	**Grafted**	**Comments**
A 140-5	**GB**	Y	2 (s)
3762	**GB**	Y	
3760	**GB**	Y	Bud Adv.
3759	**GB**	Y	
3753	**GB**	Y	
3752	**GB**	Y	
3151	**GB**	N	
Braeburn	**EM**	Y	
Cameo	**EM**	Y	