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Contents

Executive Summary

Brookdale Consulting was commissioned by East Malling Research (EMR) to assess the impact of EMR's research. This report sets out an assessment of some key areas of EMR's work, coinciding with its 100 year anniversary in 2013.

The report does not cover all of EMR's achievements, rather it includes a selection of case studies from across EMR's research.

The case studies have been selected to give the best overview of EMR's work (past, present and future) and cover:

- Rootstocks for global apple production
- Improving post-harvest quality
- Strawberry varieties
- Strawberry water use
- Pest and disease control
- Concept pear orchard

The UK horticulture industry is economically important. It has a farm gate value of some £3.0bn, a projected retail market value of £11.7bn by 2015 for fresh fruit and vegetables, around 37,000 permanent employees and a further 56,000 seasonal workers in England. The sector accounts for around 4% (175,000 ha) of the non-grass cropped area in the UK and over 300 different types of crops.

EMR has made long term contributions to the UK horticulture sector and to the sector globally.

A summary of impacts from the case studies reviewed highlights the following:

- **Historic Cumulative Impacts** – the historic impact of EMR's work in apple rootstocks and controlled storage is estimated at £8.9bn to the global economy.
- **On-going Impacts –** on-going impacts of EMR's work are estimated at £216.6m over a 10 year period (See Table 7.1). **For every £1 spent at EMR, at least £7.51 is returned to the UK economy**.
- **Operating impact -** The operations of EMR support 88 jobs and £5.1m of Gross Value Added (GVA) in the economy per year.

EMR has a strong contribution to make to future challenges facing the UK including supply chain resilience, demand for British products, climate change, water & energy efficiency, emerging pests and diseases, healthy eating, healthy ageing and food security.

EMR represents the only centre in the UK able to offer whole systems approaches bringing together science and practice in horticulture. EMR's critical mass of skills, facilities, networks and expertise has the potential to contribute to many of these challenges delivering sustainable intensification.

This will support industry growth, and assist with import substitution, exports of technology, expertise and products and potentially on-shoring economic activity back to the UK.

1. Introduction

Brookdale Consulting was commissioned by East Malling Research (EMR) to assess the impact of EMR's research. This report sets out an assessment of some key areas of EMR's work, coinciding with its 100 year anniversary in 2013.

EMR is a leading fruit research institute set up by Wye College, Kent County Council and local growers in 1913 to undertake research to address issues relating to top fruit, soft fruit and stone fruit growing in the UK. Over the years, EMR has received funding from a mix of public and industry sources including HDC, Defra and BBSRC[1].

The UK horticulture industry has a farm gate value of some £3.0bn a year and is an important part of the food and agricultural system in the UK. The sector has a considerable amount of value-added in its supply chains, with the retail market for all UK fresh fruit and vegetables projected to reach £11.7bn by 2015. The horticulture sector has around 37,000 permanent employees in England and a further 56,000 seasonal workers[2].

The sector accounts for around 4% (175,000 ha) of the non-grass cropped area in the UK and over 300 different types of crops, including field-grown and protected (glasshouse and polytunnel-grown) vegetables and salads, soft fruit (principally strawberry and raspberry), tree fruit (apples, pears, plums and cherries), flower bulb and cut flower production, bedding and hardy ornamental plants, as well as a wide range of specialised niche crops.

In many cases, market failures may apply to EMR's work. Much of its work has public good attributes. There may be risk aversion on the part of growers in adopting untested techniques or information failure about the benefits to be gained. There are externalities of EMR's work such as research spillovers which may benefit the whole industry. This is one area where EMR invests where the private sector might not. EMR's work has had application around the globe as the case studies will show. Its close links with industry mean that it is well placed to implement the findings of its research.

In the face of climate change, growing populations, food security and the need to increase resource use efficiency there is a pressing need to engage in research that can meet these challenges. EMR's work highlights the progress that can be made by targeted investment in research to address fundamental problems and the transfer of that knowledge to the field in the UK and abroad. EMR's research ranges from fundamental to applied science and EMR is ideally placed to make a strong contribution to UK and international policy in these areas.

The report does not cover all of EMR's achievements, rather it includes a selection of case studies from across EMR's research. The case studies have been selected to give the best overview of EMR's work as follows:

- EMR's contribution to apple rootstocks for global apple production
- Improving post-harvest quality
- Strawberry varieties

[1] Horticultural Development Company, Department for Environment, Food and Rural Affairs, Biotechnology and Biological Sciences Research Council.
[2] Statistics from Defra.

- Strawberry water use
- Pest and disease control
- Concept pear orchard

Within the case studies, there is a mix of historic impacts, current impacts and future potential impacts. The annual operating impact of EMR is also included. The final section of the report attempts to summarise all of these impacts.

Brookdale Consulting acknolwedges the significant contribution of EMR staff, HDC staff and industry consultees in the preparation of this report.

2. EMR's contribution to Apples and Rootstocks

Global apple production is estimated at 75.5m tonnes (FAO 2011) grown on 4.7m hectares. Global production is estimated to have increased by 53% since 1995, driven by increasing yields while the overall area harvested has fallen by 25% over the same period.

China has led this global growth and now accounts for just under half of global production at 36.0m tonnes. The USA is the second largest producer of apples (4.3m tonnes), followed by India, Turkey, Poland and Italy, each producing between 2 - 3m tonnes). UK apple production at 0.2m tonnes represents 0.3% of global apple production.

2.1 UK Apple Market

According to Defra, UK farm gate production of apples was £116m in 2012 (provisional). While the area grown has fallen, productivity has increased sharply in recent years[3].

Long term UK household apple consumption has declined from over 200g per person in the 1970s to 150 g per person by 2011[4]. Despite this fall, the UK apple market has developed strongly in the last few years with new varieties and significant increases in productivity supporting growth in UK production, allowing the UK to respond to increasing demand for home-grown produce.

Imports remain an important part of the market at between 425,000 and 540,000 tonnes per year. Much of these imports are for the canteen market as well as out of season retail. However, at the retail level, English dessert apples are firmly established as the market leaders with almost 80% of the market as shown in Table 2.1.

Table 2.1: UK retail market dessert apple market share 2013

Variety	Market share % 2013 season	Main Source
Gala	27	English
Cox	26	English
Braeburn	20	English
Granny Smith	8	South Africa[5], France etc.
Golden Delicious	8	South Africa, France etc.
Pink Lady	7	South Africa, Australia
Russetts	1	English
Jazz, Tansy, Cameo, Rubens	3	English

Source: Industry consultations

According to industry sources, 99% of the cooking apple market is Bramley and is grown in the UK.

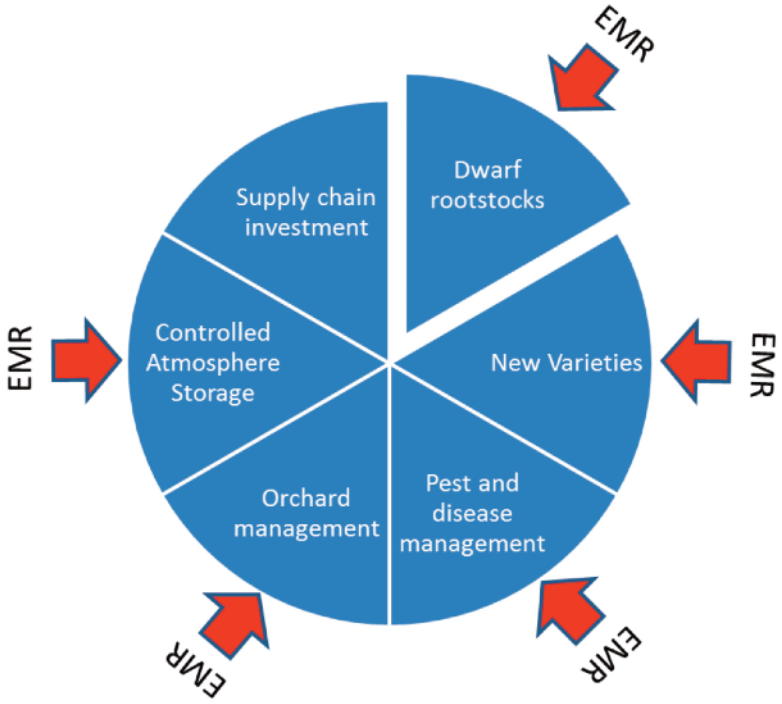
[3] See Appendix 2.
[4] Adjusted National Food Survey data 1974 to 2000, Expenditure and Food Survey 2001-02 to 2007 and Living Costs and Food Survey 2008 onwards
[5] South African apple exports to the UK have averaged 110,000 tonnes per year over the past decade but have been falling from a peak of 138,000 tonnes in 2007. The UK is around 30% of South African exports but is falling as Asia and Africa grow as destinations.

2.2 Growth in Productivity

A number of factors have contributed to improved productivity of apples and pears over the years. These factors are summarised in Figure 2.1.

EMR has had a key role in supporting productivity growth alongside Defra, HDC and industry. There has also been increased focus on provenance by UK supermarkets such that UK produce is now preferred where possible. This market 'pull' factor has been vital in supporting recent development of the industry.

Figure 2.1: Factors contributing to improved productivity of apples and pears



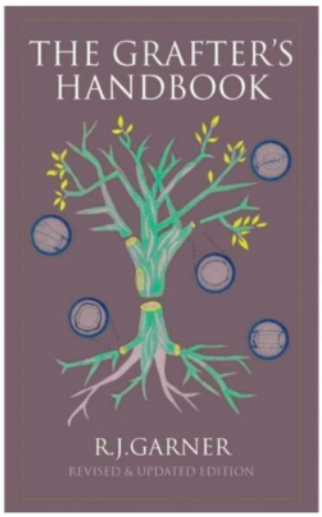
EMR's main contributions include:

- Improved rootstocks
- More effective pest and disease management – see Section 4
- Improved overall orchard management
- Improved post-harvest quality

2.3 Apple Rootstocks

The Malling M series of rootstocks was created through the collection and cataloguing of rootstocks in use across the UK and Europe. The aim was to find the best characteristics for fruit growing and to reduce the unpredictability and lack of uniformity present in most orchards.

Following extensive research, the best rootstocks were propagated and released to industry. Around 15,000 plants were released in 1921 rising to 500,000 in 1936. The 'Grafters Handbook' was also produced to share best practice with industry.



The later MM series of rootstocks (Malling/Merton) came out of a collaboration with the John Innes Centre and produced many rootstocks including MM106, widely adopted for resistance to woolly apple aphid, a serious pest of apple roots in the southern hemisphere.

Other rootstocks were developed later in other parts of the world including Russian (Budagovsky and Antonovka rootstocks with particular tolerance to cold), Geneva (from the experimental station at Cornell, Geneva, NY), P (Poland), O (from Ottawa) and Mark (from Michigan). None of these rootstocks have achieved the same prominence as EMR's.

The M9 rootstock was released in 1917. Its pros and cons are set out in Table 2.2. M9 is a dwarfing rootstock giving improved uniformity and density. It has been widely adopted across the UK, Europe and the rest of the world.

According to industry sources, M9 has an estimated 95% market share of eating apple trees in the UK and is the number one rootstock in Western Europe. It is also used extensively in North America (90% market share in USA) and South Africa.

Table 2.2: Pros and Cons of M9 rootstocks

Advantages of M9	Disadvantages of M9

• **Low compact trees**:
  ○ Fruit more quickly
  ○ Produce larger and more even fruit
  ○ More can be planted per hectare due to the small size (3-4,000 compared to old systems of 7-800 per hectare)
  ○ Resultant higher yields
• **Reduced picking costs** – industry estimates suggest labour costs associated with picking could be halved compared to using ladders.
	• **Poor anchorage** - Tree support is required with posts and wires due to brittle roots and a high fruit to wood ratio
	• **Disease susceptibility** - It is very susceptible to fire blight and woolly apple aphid.
	• **Lack of extreme cold tolerance** – where Russian rootstocks have an advantage

Source: Industry sources

No royalties are paid to EMR as the rootstocks were made freely available to the industry at the time. However, there is substantial economic value to industry from these rootstocks which explains their wide adoption. This can be valued in a number of ways, two of which are set out below.

- **Royalty value** – Based on 10p per rootstock, the number of rootstocks planted in Europe alone over the past 50 years has been estimated (see Appendix 1) giving a potential royalty value of £49m - £225m. This method would reflect the value of EMR's intellectual property had it been protected.

- **Productivity value** – another way of valuing the benefits is to estimate the value to producers of using new rootstocks released by EMR. The wide adoption of M9 is due to faster growth, improved yields and reduced picking costs (since the apples can be picked from ground level). The key period of adoption was 1920 -1960 and during this period, there were few alternatives available to growers, such that the benefits can be attributed to EMR. **A conservative assessment suggests the improved yield has provided 18m tonnes of additional apples globally as well as saving 70m hours of picking time. The additional net value to producers during this period is valued at £8.2bn in today's prices**. This values the additional yield and reduced labour costs less additional costs of staking trees[6]. Beyond this period, we assume growers had other rootstocks they could have used in the absence of M9. We therefore model the productivity improvements during 1920-1960 only in line with the assumptions in Table 2.3.

Table 2.3: Assumptions to estimate value of rootstock benefits to industry

	Unit	Total 1920-60	Assumption
Global area of orchard grown on M9	Ha	623,481	Linear increase 1920-50 to 30/50% of global area by region then flat to 1960[7]
Total tonnage of apples grown on M9	Tonnes	196,916,391	Assume 10% higher yield on M9 than average[8]
Total improved yield due to M9	Tonnes	17,901,490	Assume FAOstat baseline yields are constant over the period[9]
Labour saving	Man hrs	68,920,737	Assume saving of 3.5hrs per tonne[10]
Additional tree support	Stakes	779,351,250	Assume 750 stakes per ha and orchards replaced every 20 years
Value of yield		£5,370,447,033	@ £300 per tonne[11]
Value of hours saved		£3,609,857,366	@ £6.31 per hour[12]
Cost of stakes		-£1,000,989,250	@ £1 per stake
Net benefit		**£8,200,953,150**	

Source: FAOstat, Brookdale and industry estimates

[6] Establishment costs of new orchards are not included as it is assumed they would be incurred anyway.
[7] Global area of M9 is estimated by regions with high adoption such as Europe and USA at 50%, and low adoption areas 30%. From industry estimates, this is a very conservative assessment of adoption. Linear increase is assumed in the absence of any other information.
[8] A nominal yield increase to take account of improved productivity and faster growth.
[9] There is evidence to suggest yields were fairly static between 1920 and 1950 but began to rise after that time, presumably as planting densities increased, supported by advances in pest and disease management. (See Appendix 2 for UK yield figures).
[10] Based on industry assessment of ladder systems compared to Agricultural Budgeting and Costing Book No. 75 November 2012 which suggests £60. At £8 per hour this is 7.5hrs.
[11] Value and yield figures from FAOstat for different global regions.
[12] Average wage weighted for Africa/Asia/Eastern Europe to reflect pay differentials using ILO global wage report.

Industry continues to use M9 and other EMR rootstocks around the world. However there is a need for future research into rootstocks with potential for improved water utilisation, drought tolerance, improved vigour and pest and disease resistance. EMR is working on new rootstocks to meet these objectives.

2.4 Post-harvest quality

The Produce Quality Centre is a collaboration between EMR and the National Resources Institute of the University of Greenwich. Much of EMR's current research into post-harvest quality involves both parties.

2.4.1 Controlled Atmosphere Storage from the 1920s

The original rationale for controlled atmosphere (CA) storage in the 1920s was to improve storage conditions on-board ship such that the UK could import apples from Australia and New Zealand. This was seen as particularly important for the UK's food security at that time.

Research at EMR in the 1920s discovered the role of ethylene in control of apple ripening. By controlling temperature, O_2 and CO_2 levels in-store, and through the use of inhibitors, ethylene production can be reduced and storage times lengthened.

Without CA, apples can only be stored until late November. As CA has developed, EMR has undertaken empirical analysis of the best regimes which vary for each variety.

As well as supporting imports and the UK's food security, this work became the foundation for development of post-harvest storage systems for apples, thus lengthening the marketing season.

The impact of CA storage can be estimated as follows:

- Assume a straight line increase in storage capacity from 1930 to 1945 when 30,000 tonnes of CA storage was in place. Assume that rate of increase continues to 1970.
- After 40 years, assume that the benefits of the original innovation are now superseded by other research.
- Assume that losses in-store are 20%.
- Assume that without storage, crop has no value.
- Assume that costs of storage are 25% of the sale price of £533 (today's price from FAO).
- Assume that the uplift in price is 25% of the sale price of £533
- Impact is therefore, amount of storage in any year less losses multiplied by value less costs of storage.

On this basis, the net value of EMR's research in CA storage from 1930-1970 is an additional 1.3m tonnes of apples worth £700m in today's prices.

2.4.2 Controlled Atmosphere Storage Now

From original work in apples, the research has now been extended to other crops such as plums, cherries, tomatoes, potatoes and broccoli and researchers world-wide are developing

improved storage regimes. Reducing losses post-harvest is worth much more than reducing losses in the field due to the value added to the crop as it progresses through the supply chain.

In the late 1990s it was only possible to store English Gala till end of January. Now it is possible to store until June. Bramleys have 12 months of continuous supply due to year round storage. Industry anticipates that within 10 years, it will be possible for UK dessert apples to supply 12 months of the year.

EMR has a current project at the Produce Quality Centre on UK Gala. The aim is to develop the best storage protocols to maximise flavour for longer. This is funded half by HDC and half by six companies to a total of £45,000. If successful it could displace apple imports to the UK.

2.4.3 Post-harvest pathology

From 1954 it took 17 years to refine storage methods for Cox allowing it to be marketed through to mid-February. However, in 2000 a condition called diffuse browning disorder (DBD) was found to spoil Cox apples in-store with no apparent solution. EMR researched this disease extensively through a series of HDC and Defra funded projects and discovered that it was related to the use of azole compounds in pesticides. When use of the compounds was stopped, incidence of the disorder dropped significantly. The results of the work were shared with industry and it is now accepted practice in Cox production.

The key impacts of DBD were:

- In-store losses with a farmgate value £210 per tonne[13]
- Examples of whole store losses worth £23,100 per grower[14]
- Resulting lack of confidence in storing Cox due to the threat of DBD
- Forced marketing at harvest when prices are low due to over-supply of dessert apples.

The solution is to use non-azole pesticides or where azoles are used, to market apples at harvest. Through management changes, therefore, the disorder is now much better controlled with only very small outbreaks.

Although no accurate figures exist, assuming 10 stores were affected with total losses per year and a further 10 with 10% losses would suggest an annual impact of £254,000 – these losses now being avoided.

Research is on-going to assess what happens to various pathogens with different varieties in crop storage. Losses due to disease can easily be 5-10%. EMR's research is leading to reductions in losses where every 1% reduction in Cox losses is worth £0.29m[15]. **Across all**

[13] Based on industry estimate of average value for dessert apples of £240 less value as juice of £30 per tonne making £210 per tonne.
[14] Based on a typical store size of 110 tonnes at £210 per tonne
[15] 2011 value of HPM cox apples was £29.4m according to Defra Basic Horticulture Statistics. 1% of this is equal to £0.29m

UK apple production, EMR's work is reducing losses where every 1% is worth £1.2m per year at the farmgate[16].

2.4.4 Pre and Post-harvest innovations

A range of other areas of impact where the benefits have not been quantified include the following.

EMR's fundamental research uncovered the role of auxins in controlling fruit drop. This led to the development of auxin sprays to delay pre-harvest drop of fruit.

EMR has developed pre-harvest best practice regimes to optimise fruit yield and quality and published a best practice guide for apple and pear production and storage. For example, the best picking time and how long it can be stored for. The future is for bespoke plans for each orchard depending on soil type and pollination time.

EMR has also researched mineral nutrition e.g. calcium, boron and zinc. These minerals are influenced by rootstock, weather, sunlight and management. Better understanding of what influences mineral content can improve yield and reduce diseases.

[16] 2011 value of all HPM apples was £111.8m according to Defra Basic Horticulture Statistics. 1% of this is equal to £1.2m

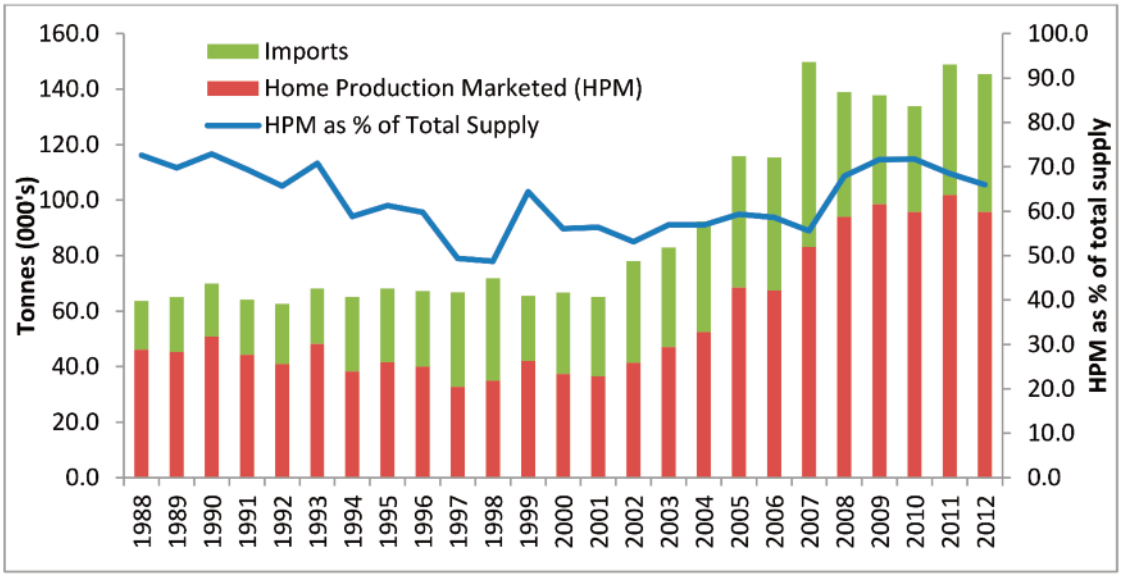
3. EMR's contribution to Strawberries

3.1 UK Strawberry Market

According to Defra, the farm gate production of strawberries was 100,000 tonnes worth £280m in 2012, double the 2003 level of production. At the same time, self-sufficiency has risen from 50% to 66% as shown in Figure 3.1.

Household consumption of soft fruit has more than doubled from an average of 20g in the 1970s to 46g per person in 2011. Strawberries have moved from being a summer treat to a year round healthy food.

Figure 3.1: Home production, imports and self-sufficiency for UK strawberries 1998-2012



Source: Basic Horticulture Statistics, Defra, 2012

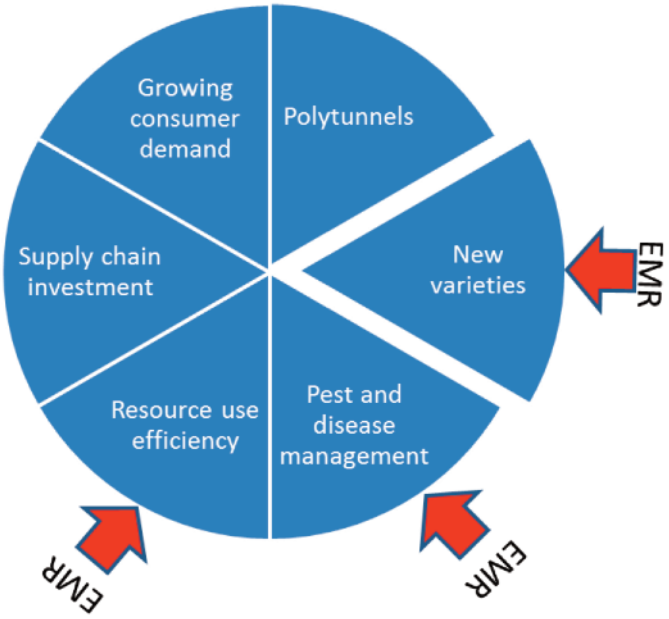
Consumer popularity has meant that alongside increased UK production, imports have increased from 7,000 tonnes in 1998 to 22,000 tonnes in 2012 to fulfil out of season demand. However, in-season imports have reduced from 17.5m to 12.5m kg (June to September).

3.2 Growth in Productivity

A number of factors have contributed to improved productivity of soft fruit over the years and strawberries in particular. These factors are summarised in Figure 3.2.

EMR has had a key role in supporting this productivity growth alongside Defra, HDC and industry.

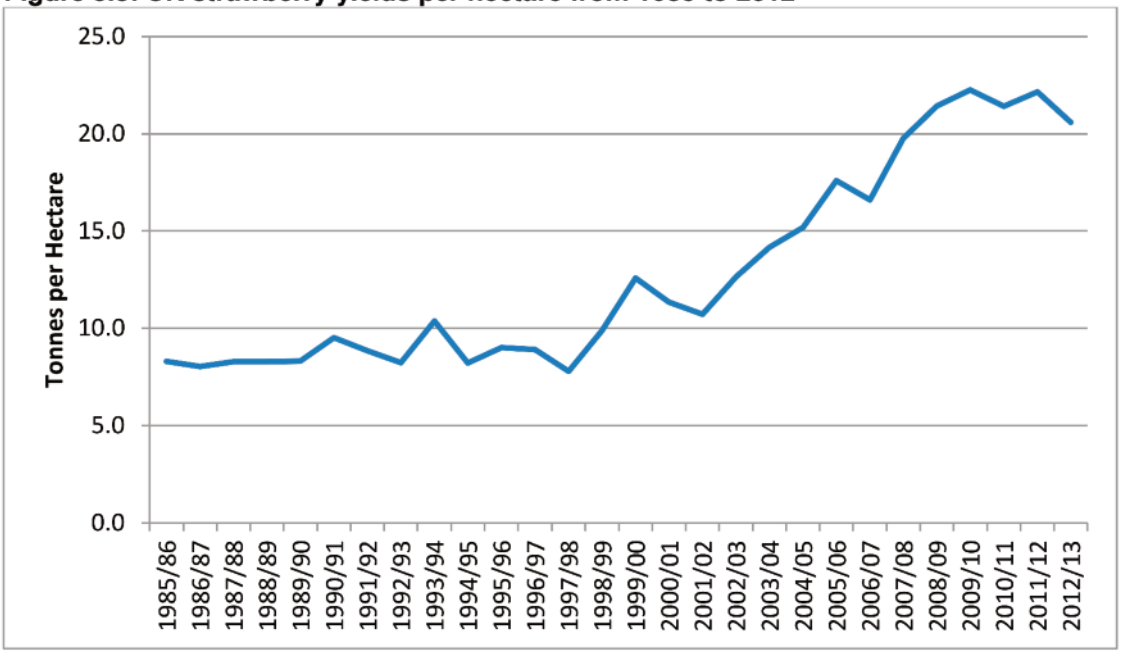
Figure 3.2: Factors contributing to improved productivity of strawberries



A key role of EMR has been to introduce high yielding new varieties to extend the UK season at both ends, thus helping to displace imports. Alongside polytunnels and improved management, new varieties have been key in supporting productivity growth.

Figure 3.3 shows the increase in yields achieved, to more than double the level of the 1990s.

Figure 3.3: UK strawberry yields per hectare from 1985 to 2012



Source: Basic Horticulture Statistics, Defra, 2012

3.3 Strawberry varieties

EMR started breeding new strawberry varieties in 1983 and since 1988 has released 38 varieties to meet the requirements of all sectors of the strawberry industry, including commercial and amateur production. Sales of EMR strawberry plants were worth £27m to nurseries in 2012 and it is estimated that EMR has around a third of UK market share.

'June-bearers' are traditional strawberry varieties that produce a predictable crop in the normal season. 'Ever-bearers' are continuous fruiters, traditionally cropped from mid-July to October as their fruit quality has been poorer than June-bearers and production less predictable.

Key benefits resulting from these new varieties have been:

- Improved yield, fruit size and quality
- Reduced wastage by increasing the proportion of Class 1 fruit
- Increased pest and disease resistance, leading to reduced pesticide use and residues
- Easier picking – a function of fruit size and more upright and open plants
- Extension of season by introducing June-bearers 7-10 days ahead (e.g. 'Vibrant'), *and* up to 4 weeks later (e.g. 'Judibell'), than leading current industry standards, 'Elsanta' and 'Sonata' (Dutch varieties);
- Extension of season by introducing higher-yielding, better quality ever-bearers that crop from July through to October.

EMR's varieties are used primarily in the UK and Northern Europe, though some varieties have taken off in the USA and South Korea with potential now being developed in China.

In South Korea, the EMR variety 'Flamenco' is grown for export to Japan as a luxury product where a small box of perfect strawberries can sell for £20.

'Flamenco' has the right shape and sugar content for this market.

EMR has on-going research to further improve productivity as follows:

- **Ever-bearers** - EMR is developing new ever-bearer varieties with improved fruit quality that could allow plants to crop right through the season. Growers typically plant some early and some late varieties. With improved fruit quality ever-bearers could be cropped from May through to October thus reducing costs associated with the space and husbandry requirements for two plantings. If EMR can develop consistently performing ever-bearers, these are likely to be rapidly adopted by industry.

- **Programmed cropping** – EMR has developed two varieties: Elegance (late) and Vibrant (early) that give higher yields in programmed cropping[17]. They also have the advantage of reverting to their natural cropping season the following year thus avoiding over-production from the use of mid-season varieties 'Elsanta' and 'Sonata'.' Elegance' and 'Vibrant' have been successfully released to the industry, with excellent uptake both in the UK and the Continent. A June-bearer initiates flowers during autumn then enters dormancy. By lifting in winter, these plants can be kept dormant in a cold-store and planted from May onwards to yield a very predictable crop 60 days later. This allows growers to 'programme' production to their customers' requirements. While the system was devised for industry standards 'Elsanta' and 'Sonata', it has not historically worked for every variety, including those that might have better fruit quality or give an earlier or later production in the following season. However EMR's work in understanding the inheritance of these traits has led to the development of these two new varieties with resultant benefits to growers

- **Molecular Marker Breeding for Disease and pest resistance** – EMR is breeding improved resistance into all varieties which reduces costs of sprays, wastage and allows reductions in soil fumigation. Recently, EMR has implemented a novel molecular marker assisted approach[18] which will focus on introducing multiple and durable resistance to key diseases such as Verticillium wilt, crown rot and powdery mildew. Strawberries accounted for 55% of the pesticide-treated area while soil sterilants accounted for 57% of the total weight of pesticides applied in 2010[19]. At the same time, these diseases are a substantial cost to industry where any reductions will save costs for producers and reduce environmental effects.

[17] 400g per plant versus 230g per plant for Elsanta which is 1.75 times the yield.
[18] By drawing upon a range of BBSRC, HDC and TSB funded work and feeding it into the Programme.
[19] Pesticide Usage Survey 2010

- **Heat tolerance** – EMR is identifying lines that show tolerance to high summer temperatures, and thermo dormancy, where plants shut down and stop producing fruit. The variety 'Finesse' is one example here.

- **Table-top production** – EMR is developing specific varieties suited to table-top production.

Alongside polytunnels, new varieties have transformed industry productivity as well as allowing growers to achieve higher prices out of main season. For example, from 1998 to 2008, industry yields increased by 100%, from 10 to 20t/ha.

It is not possible to strip out the effects of different factors in contributing to these productivity increases. Therefore, in Table 3.1 we have modelled small (1%) changes in the factors of production to assess what the main contributions of EMR have been as follows:

- Yield per hectare 1% increase
- Price per tonne 1% increase
- Crop protection cost 1% reduction
- Casual labour cost 1% reduction

Table 3.1: Financial effect of varietal improvement on gross margin of strawberries

Gross Margin for Typical Strawberry Farmer			Ongoing impact of EMR Varieties		
Category	**Assumption**	**£ per Ha**	**Average annual impact**	**Increase per ha**	**£ per ha**
Yield	20 tonnes per ha	20.0	1.0%	0.20	20
Price	2750 per tonne	£2,750	1.0%	£27.50	2,778
Output		**£55,000**		**£1,106**	**56,106**
Establishment	@ 33.3% share of cost	£3,200	0.0%	£ -	3,200
Structures	Polytunnels	£5,000	0.0%	£ -	5,000
Fertiliser	110N:40P:80K:50M kg	£ 209	0.0%	£ -	209
Crop Protection		£ 950	-1.0%	-£ 10	941
Casual Labour	Hand picking, packing and field work	£ 20,000	-1.0%	-£ 200	19,800
Containers	Including sundries	£7,000	Proportional to yield	£ 70	7,070
Marketing	@ 10% of output	£5,500	Proportional to output	£ 111	5,611
Variable Costs		**£41,859**		**-£ 29**	**41,830**
Gross Margin		**£13,141**		**£1,134**	**14,275**

Source: Agricultural Budgeting and Costing Book No. 75 November 2012

The calculations presented above estimate the annual impact of EMR varieties on gross margin at £1,134 per hectare, which is equivalent to an increase of 8.6% to the gross margin of a typical strawberry farmer using industry standard varieties.

Assuming 40% of the industry adopt the EMR varieties and achieve these benefits[20], indicates that **the annual gross margin attributable to EMR is just over £2m each year.**

3.3.1 Import Displacement

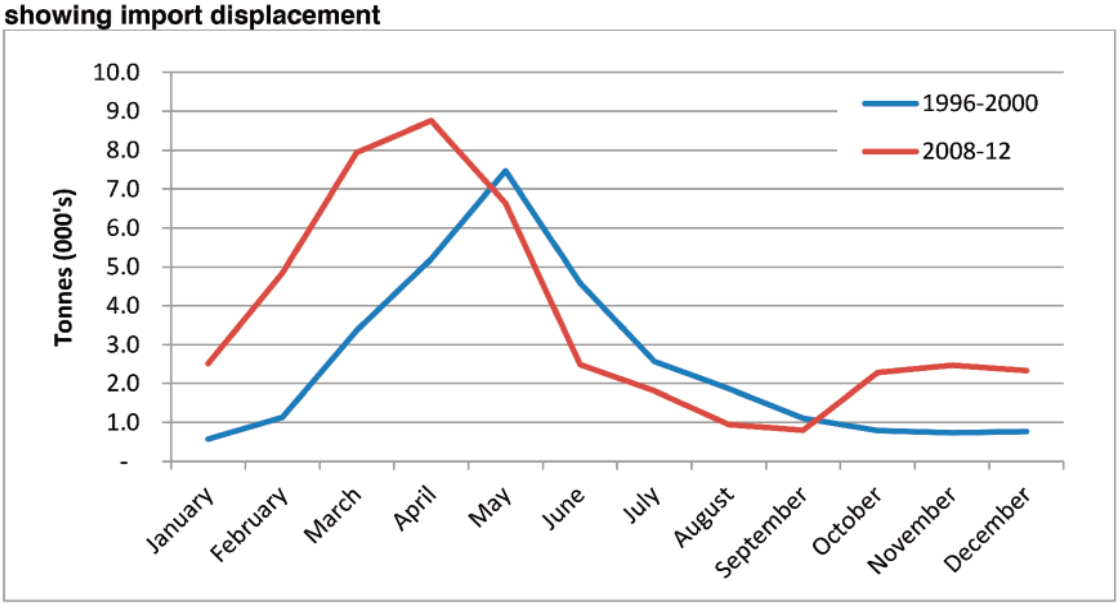
Supported by EMR, the industry has been able to displace imports in the historic peak period of May. Figure 3.4 shows a comparison of imports in 1996 to 2000 and 2008 to 2012.

- The blue line illustrates the historic imports of strawberries peaking in May.
- The red line shows more recent imports, with the peak moving earlier to March/April.

While imports are now higher than in the past, this represents overall growth in the UK strawberry market. The important point is that even with the increase in demand; **the UK is importing less in summer months and extending the season at either end.**

The data suggest that 5,000 tonnes of strawberry imports with a farm gate value of £13.75m have been displaced by increased home production. **Assuming that half of this increase can be attributed EMR suggests a net impact of £1.64m per year based on additional gross margin**[21].

Figure 3.4: Comparison of UK strawberry imports 1996 to 2000 with 2008 to 2012 showing import displacement



Source: HMRC

[20] Based on the UK area of 4,800 ha, 40% being 1,840 ha and a net benefit of £1,134 per ha giving £2.087m annual benefit.

[21] 5,000 tonnes equates to 250 ha at a yield of 20 tonnes per ha. The Gross Margin per ha is £13,141 giving a total impact of £3.28m. It is impossible to accurately attribute this impact; however, the two major factors are polytunnels and EMR's research. In the absence of other information, we assume half the impact is due to EMR (£1.64m).

3.3.2 Reduced Water use

EMR has been working to improve resource use efficiency of crops. EMR estimates that 85% of UK horticultural production is within areas of water shortage. With climate change, food security and likely future scarcity of water, this is an important area of research to improve sustainability of production.

Work in this area has researched the response of plants in soils and substrates to water stress. EMR has undertaken research to reduce water usage in both of these systems. Work on soil-grown strawberry production has been funded by Defra HortLINK projects[22], HDC, TSB and private sector. The final two years of the project involved field trials with commercial growers.

EMR's research in strawberries is now starting to have substantial impact on growers. Many growers increase irrigation to maximise yield, though this can lead to softer fruit that is easily bruised and less tasty. EMR has shown that it is possible to reduce water use substantially while improving quality and is now working with industry to implement the savings.

Typically drip or trickle irrigation systems are used as these are the most efficient. EMR has found average water usage fall in commercial production from 78l of water (2007) per kg of Class 1 fruit to 44l of water (2011).

Despite this decreased use of water, EMR has found a wide range of water use in commercial production from 16-120l of water per kg of Class 1 fruit.

Soil Grown - In two years of experimental field trials, the following benefits have been achieved in soil grown strawberry systems:

- 36% saving in water
- Improved fertiliser use efficiency
- 18% increase in Class 1 yield
- Reduced picking costs as foliage is reduced and fruit is more visible
- Improved performance in taste tests with leading supermarkets

This work is being implemented with a leading producer group accounting for around 40% of UK strawberry production and is expected to be adopted over the next few years. The key challenge is convincing growers of the benefits.

Substrate grown - normal practice is to allow 10-25% of water to run through the crop and drip out underneath. This prevents the build-up of salts in the substrate. As fertiliser is dissolved in the water, this wastes fertiliser too. EMR has found that it is possible to eliminate run-off of water without affecting yield or quality. This has led to a 45% water saving in experimental trials, dropping to 17% in trials with the most water-conscious producers. A leading producer group is now funding work to take it forward for substrate growers.

[22] For soil production funding was £429,247 from 2007 to 2012 while for substrate production funding was £939,000 from 2007 to 2012.

Costs

Implementing the system in either soil or substrate grown systems usually involves a water audit of the grower's irrigation system, and possibly some modifications to pipework to ensure correct pressures are achieved across the system. Growers may also require training. These costs have been estimated as follows:

- Water audit £500 one off cost
- Irrigation system modifications £2,000 on average per grower one off cost
- Training and implementation – assume 10 hours at £30 per hour to include grower's time and any group training giving £300 one off cost.
- **Total costs per grower £2,800**

Benefits

Table 3.2 shows a typical gross margin for strawberry growing in the UK. We assume a conservative average reduction of 20% in water use across the industry for the purposes of assessing impact. Alongside the typical values, we show the financial effects of the improvements in water usage, yield and quality. Taken together, **these benefits translate to an uplift of £8,100 per hectare**. We assume that these savings apply to both soil and substrate grown systems.

Table 3.2 Financial effect of improved water use on gross margin of strawberries

		Typical £ per Ha		Increased £ per Ha
Yield	20.0t @ £2,750/tonne	55,000	18% increase in yield	64,900
Output		**55,000**		**64,900**
Establishment	@ 33.3% share of cost	3,200	No change	3,200
Structures	Polytunnels	5,000	Add costs of water audit training and irrigation modifications spread over 5 years (£2,800/5)	5,560
Fertiliser	110N:40P:80K:50M kg	209	Assume 5% reduction	199
Crop Protection		950	No change	950
Casual Labour	Hand picking, packing and field work	20,000	Assume 5% reduction in labour	19,000
Containers	Including sundries	7,000	18% increase	8,260
Marketing	@ 10% of output	5,500		6,490
Variable Costs		**41,859**		**43,659**
Gross Margin		**13,141**		**21,241**

Source: Agricultural Budgeting and Costing Book No. 75 November 2012

Financial benefits – In 2011/12, 101,900 tonnes of strawberries were grown on 4,648 hectares with a farm gate value of £245m[23]. **Assuming adoption of new water saving irrigation scheduling techniques for 40% of production over three years, and assuming**

[23] Source: Basic Horticulture Statistics 2013, Defra. Average Class 1 yields achieved by growers are 20-23 t per ha but the best growers achieve yields of up to 38 t per ha. This yield gap is partly due to the 30% wastage during production caused by over-irrigation resulting in skin crazing, cracking, unacceptably soft fruit, and proliferation of diseases such as Phytophthora.

the full benefits are achieved by growers, the annual benefits would be £3.8m rising to £15.1m:

- Year 1 – assume 10% adoption = 465 ha *£8,100 = £3.8m
- Year 2 – assume 20% adoption = 930 ha * £8,100 = £7.5m
- Year 3 onwards – assume 40% adoption = 1,860 ha* £8,100 = £15.1m

Assuming that the additional strawberries displace imports, these benefits can be considered as net benefits to the UK. Consumers would also benefit from improved fruit quality and taste at no extra cost.

Costs of water - At the moment, most growers do not pay for their water, rather they collect water or have abstraction licences to draw water from streams and rivers. The cost of such water simply reflects the cost of the licensing scheme (£0.003 -£0.06/m^3) and there is concern that the true cost of the water is not accounted for.

The National Ecosystem Assessment suggests that the true value of water for horticulture should be around £1.50 per m^3 so we have used that figure to estimate the value of water saving that this work could provide to the UK[24]. This is not a market price, rather it reflects the wider social and environmental costs of water use which are likely to increase in the face of climate change. Table 3.3 shows that on the basis of the assumptions above, **the value of this water saving to the UK is £0.53m per year.**

Table 3.3: Value of saving in water in strawberry production

Strawberry Production (tonnes)	101,900
Water use per tonne (cubic metres)	44
Efficiency saving	20%
Adoption rate	40%
Value of water (cubic metres)	£1.50
Water saving (cubic metres)	358,688
Value of water saving	£538,032

[24] UK National Ecosystem Assessment Working Paper: Economic Assessment of Freshwater, Wetland and Floodplain(FWF) Ecosystem Services, Cranfield University, 2011

4. EMR's contribution to pest and disease control

There are many examples of EMR's work in improving pest and disease control in both soft and top fruit over many years. It is not possible to review all of these examples so a selection is set out below. Key objectives of research have included:

- Reducing costs to producers by finding new solutions to pests and diseases
- Limiting environmental side effects of pesticide use
- Minimising the incidence of pesticide residues.

A particular feature of the work has been to introduce Integrated Pest and Disease Management (IPDM) such that requirements for pesticides are reduced along with unwanted side effects such as toxicity or reduced biodiversity. EMR's close links with industry have been vital in demonstration and adoption of new techniques.

Fruit Tree Red spider mite - became a serious problem in apples and plum orchards in the 1940s and 1950s following extensive use of chemicals which killed its predators. In the 1970s EMR developed a system of integrated mite management that conserved natural predatory mites that could control red spider mite thus making acaricide use largely unnecessary. This work became the foundation for modern IPDM. Growers adopting IPDM for red spider mite could avoid at least two sprays per year leading to a saving of £120 per hectare in spray costs at today's prices. **Assuming minimal management costs to introduce and adoption over half of the UK's apple and plum area, suggests an annual saving of £0.92m to the industry**[25].

Capsid bugs - with the extension of season in soft fruit, EMR recognised new pests such as the European Tarnished Plant Bug and Common Green Capsid which cause misshapen fruit, thus reducing Class 1 yields. EMR devised new management controls using sex pheromone traps to monitor populations and identify when to spray, rather than spraying routinely. These methods are now widely adopted by industry. If effective controls are not applied, over half the crop can be lost. **Extensive heavy losses were avoided in the early years and ongoing use of EMR's control methods mean that average crop losses in late season strawberry from this pest have been reduced from >5% to < 1%, an annual saving of £0.57m**[26]

Reducing pesticide use – a key aim of EMR's work is to reduce pesticide use across the board. This reduces costs to growers, allows them to comply with independent quality assurance schemes, and reduces unintended side effects of pesticides and pesticide residues in fruit. For example, with rosy apple aphid, EMR's lifecycle research showed the best time to

[25] 15,305 ha in 2012 (provisional) Defra. 15,305*50%*£120=£918,300.
[26] 95,700 tonnes * 25% (proportion of crop impacted) * 4% (reduced losses) * £657 (margin per tonne) - £60,000 (cost of traps 300 grower * 100 traps each * £2 per trap)

apply sprays. This was totally different to the perceived wisdom of the time leading to completely new regimes with reduced applications and better protection. **Assuming a reduction of one spray per season and adoption over half of the UK's fruit production area, suggests an annual saving of £0.87m to the industry[27].**

According to industry sources, improved disease control and improved orchard management have seen grade out rates for Cox increase from a typical 60% in 1990 to 75-80% now. For Gala, 90% grade out rates are achieved now, this level being required to compete with imports. **The value of improved apple grade-out rates is £7m for every 10% improvement achieved at the farm-gate with EMR's work playing a key role alongside general management improvements.**

Spotted Wing Drosophila (SWD) – this fruit fly lays its eggs in ripening fruit leading to larvae spoiling fruit at harvest. It has reduced yields of soft fruit and stone fruit in affected areas of the USA by 16% ($421m)[28] and has also affected parts of Europe. EMR alerted the industry to the threat and was the first to spot it in the UK in August 2012.

EMR is now leading a £750k[29] industry-wide project to assess the risks, monitor the situation and to ensure appropriate insecticides and other controls are available. EMR has informed and trained the whole of the UK soft and stone fruit industry on best management practices including sprays and precision monitoring. EMR's inputs are helping to minimise losses from SWD in UK soft and stone fruit production. The impact can therefore be calculated as follows:

Costs

- Industry-wide project £750k
- Assume that the south east of England is most at risk which is 46% of the UK area of soft fruit or 4,440ha[30].
- Industry costs in training and awareness £42,000. Assume 300 growers at £140 each based on 7 hours training and management at £20 per hour.
- Industry costs in sprays and trapping £1.386m. Assume 5 sprays at a total cost of £300 per ha across 4,440 ha and 100 traps per grower at a cost of £2 each.
- Total costs £2.178m.

Benefits

- Avoided losses of up to 16% (taken as the maximum figure though industry estimates suggest it could be higher)
- Assume the same area is at risk as above which is 46% or 4,440ha.
- Although 75%[31] of the area is grown under cover and might be thought to be protected, industry consultations suggest all areas are likely to be affected.

[27] 29,115 ha of fruit * 50% * £60. The Pesticide Usage Survey highlights long term reductions in both the active weight and total weight of insecticides applied in strawberries.
[28] Bolda, Goodhue, and Zalom (2010) Spotted Wing Drosophila: Potential Economic Impact of a Newly Established Pest.
[29] HDC £614k, Defra £70k, Scottish Government £74k. Other partners include NRI and James Hutton Institute.
[30] Defra Basic Horticultural Stats record 9,653 ha in 2012/13. The Pesticide Usage Survey states 29% of soft fruit is grown in London and the South East and 17% in East England making 46%=4440ha.
[31] The Pesticide Usage Survey states that 75% of soft fruit is grown in polytunnels.

- Since SWD have already been detected in the UK it is assumed that without intervention the losses stated occur in a given year.
- Assume that through preparedness, all losses are avoided.
- Assume that the farm gate value per ha is £36,652[32]. 16% loss = £5,864, 8% loss = £2,932.
- Total avoided losses are therefore £26.3m at 16% or £13m at 8%[33].

The net benefit of mitigating a SWD outbreak, therefore, ranges from £10.8m to £24m. EMR's share of impact, based on project funding[34], would be 67% or £7.2m-£16m.

A range of other areas of impact where the benefits have not been quantified include:

Powdery Mildew Forecasting Model – industry is adopting a model developed by EMR and University of Hertfordshire into commercial practice in soft fruit allowing it to reduce mildew sprays and save money.

Scab – EMR's work highlighted the importance of clearing orchards to remove infected leaves and stop over-wintering of pathogens. While this increases labour costs, it leads to better crops the following year with increased quality and percentage of marketable produce along with reduced use of chemicals.

Soft fruit viruses – plant viruses can have a major impact on yield. EMR developed the first ELISA tests for viruses in the 1960s to allow development of virus free soft fruit and tree fruit working with the Nuclear Stock Association. This work has had a major impact on productivity of all fruit crops.

These areas represent a selection of EMR's overall ongoing contribution to pests and diseases.

[32] Defra Basic Horticultural Stats
[33] 4,440 ha*£5,864 or 4,440 ha*£2,932
[34] EMR's project funding is £500k out of the total £750k

5. Concept pear orchard

The concept pear orchard aims to compare three different continental systems of high density planting with the traditional extensive pear orchard system typical in the UK.

Pear orchards have been in decline in the UK over many years due to a perceived lack of profitability. Typical yields are 18-22 tonnes per hectare with the current UK farm gate value being £15m[35]. EMR's work is establishing whether yields and profitability can be improved making pears more viable as a UK crop.

The concept pear orchard was planted in March 2009 and is now in its fourth crop. Results so far indicate:

- An extra 200 tonnes of pears per hectare during establishment phase[36]
- Average yield of the three high density systems of 51 tonnes per hectare.
- This is 2.3 times a typical UK system
- Compares with 37 tonnes per hectare for an intensive version of a typical UK system.
- Higher percentage of Class 1 fruit.

It is expected that even higher yields will be achieved once the orchard matures.

The orchard also provides an opportunity to adopt EMR integrated pest and disease management recommendations and other research. For example:

- Pear sucker - a major pest of pear orchards. Five hosts known to attract predators for pear sucker have been planted. These hosts are Hawthorne, Hazel, stinging nettle and two types of willow. It was only necessary to spray for pear sucker once during 2013, while in Holland they sprayed 2-3 times.
- Water use efficiency – EMR is working on an HDC funded project to further improve water use efficiency.

The concept pear orchard has much higher establishment costs per hectare than a typical UK system due to the density of trees being five times a typical orchard and the cost of additional supports and wires. These higher costs should be recovered through the increased yields as shown in Table 5.1 which shows a gross margin £4,984 higher per ha for the new system:

[35] Defra

[36] Traditional orchards do not give any fruit until Year 6/7. The concept per orchard has yielded from the first year with the cumulative yield up to Year 6/7 being estimated at 200 tonnes.

Table 5.1: Financial effect on gross margin of adopting concept pear orchard

	Typical UK system £ per Ha		Concept pear orchard £ per Ha	
Yield	22.0t @ £550/tonne	12,100	51t @ £550/tonne	28,050
Output		**12,100**		**28,050**
Establishment	@£15k spread over 18 years	833	@£35k spread over 18 years	1,944
Fertiliser	110N:38P:80K:50M kg	207	Assume 2.3 times	518
Crop Protection		650	20% increase	780
Casual Labour	Picking £60 per tonne, grading and packing £135 per tonne and pruning £550 per hectare	4,840	As per typical system except pruning at £1,265 per hectare, 2.3 times the cost	11,210
Packaging	£50 per tonne	1,100	£50 per tonne	2,700
Marketing	@ 10% of output	1,210	@ 10% of output	2,805
Variable Costs		**8,841**		**19,807**
Gross Margin		**3,259**		**8,243**

Source: Agricultural Budgeting and Costing Book No. 75 November 2012 Compared to EMR figures from Concept Pear Orchard.

Assessing the benefits to industry over 10 years suggests an additional £14.3m in net benefits to producers based on the following assumptions:

- Adoption of the system at 5% of current area per year up to 30% of area then constant. Assume it takes 4 years to reach 51 tonnes per ha. Yields in years 1-3 are 10, 19 and 24 tonnes respectively based on EMR trials.
- Compare with traditional system which gives no yield in years 1-5, 15t in year 6 and 22t in year 7.
- Once in steady state the annual benefit is £2.2m[37]
- No change in yields or total area over the 10 years

This value would rise further if yields rise as anticipated as the concept orchard matures.

In the absence of EMR's work, it is unlikely that UK growers would adopt the system as growers are conservative and it would not be seen as tried and tested in the UK climate.

According to industry sources, the UK retail market for pears is worth £166m, of which half (£88m) is for Conference pears. This market is met by home production of £31m and £57m of imports at retail level, mainly from Belgium and Holland, with Spain and Italy to a lesser extent. UK supermarkets are keen to purchase UK pears but the industry cannot supply them. **Once at 30% adoption, EMR's work could therefore allow the UK industry to supply at least a further 13,000 tonnes of pears displacing foreign imports worth £14m retail value per year.**

[37] Basic Horticultural Statistics 2013 show 2012 UK pear production as 25,800 tonnes over 1,471 hectares worth £15m. Average yield is 17.5 t/ha. 30% of the area is 441 ha * 4,984 (the additional gross margin) = £2.20m once both systems are fully established.

6. EMR's other impacts

6.1 Operating Impact

The operating impact of EMR relates to the on-site running of the Institute, such as expenditure incurred and staff employed, and also the knock-on effects as these expenditures ripple through the UK economy and support further activities. The total economic impact of operating EMR therefore encompasses three distinct elements:

1. **Direct impact**: output generated and persons employed in the day-to-day operation of the Institute;

2. **Indirect impact**: output and employment created in the businesses which supply the inputs or materials used by the Institute; and

3. **Induced impact**: output and employment created when workers employed directly or indirectly spend their income in the local economy.

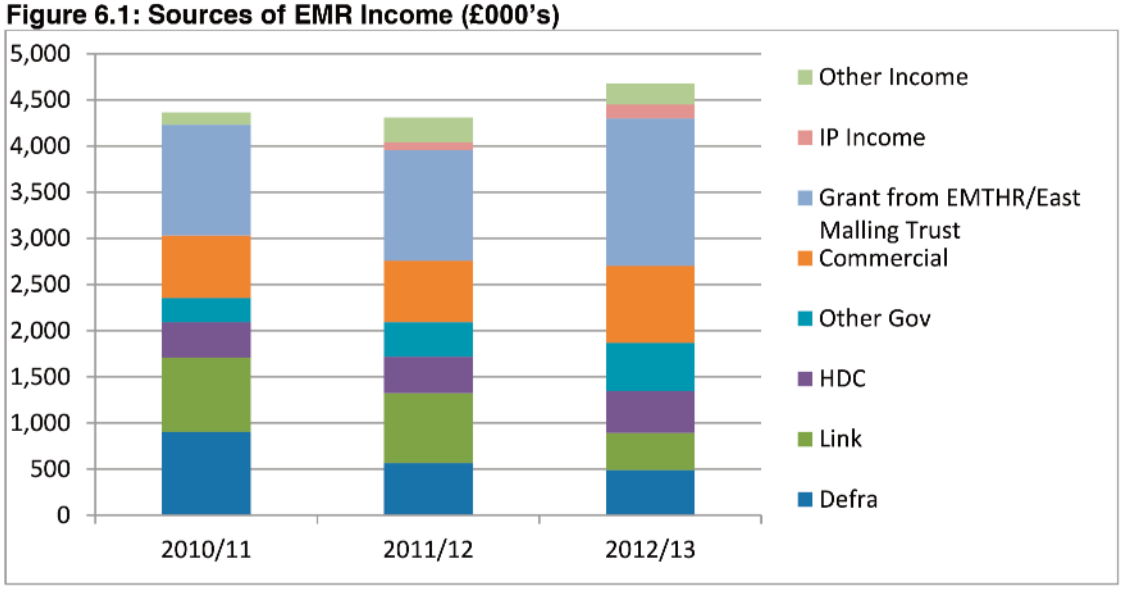
These elements are set out below then summarised in Table 6.1 at the end of this section.

6.2 Direct Impacts

6.2.1 Income

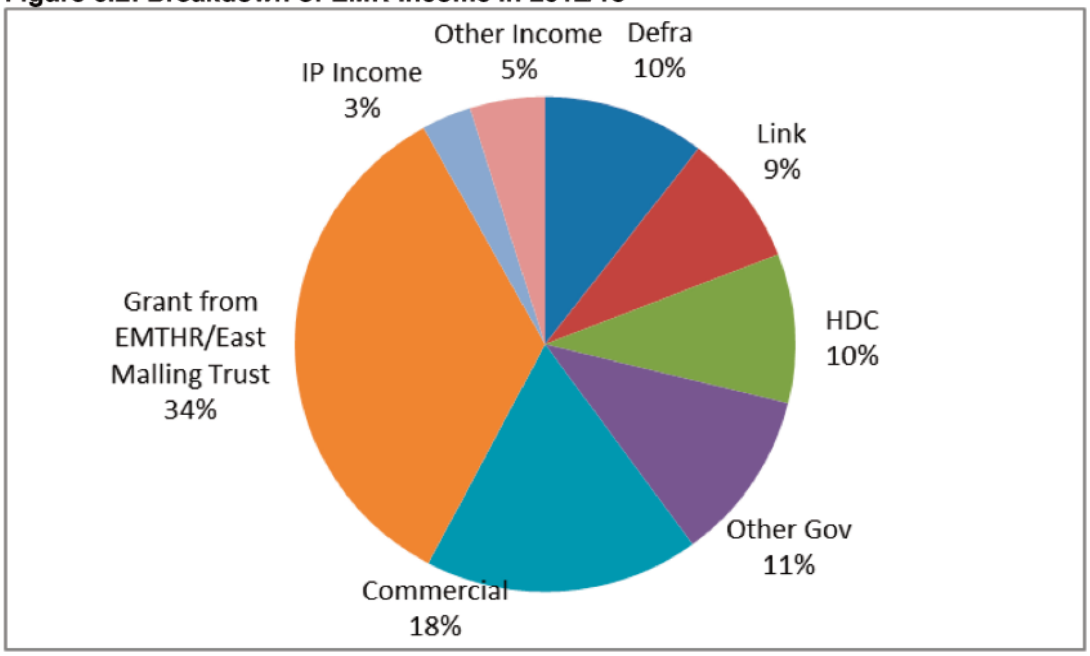
EMR's income in 2012/13 was £4.528m. Figure 6.1 illustrates income by source over the last 3 years. The main change during this period has been a reduction in Defra and LINK funding as Defra has moved away from funding research; and an increase in funding from other sources.

Figure 6.1: Sources of EMR Income (£000's)



There is a high level of income from commercial sources and industry levy in comparison to most Institutes at 31%[38] of total. Income from public sector sources represented 30% of the total in 2012/13, while the grant from EMTHR/East Malling Trust represented 34%.

Figure 6.2: Breakdown of EMR Income in 2012/13



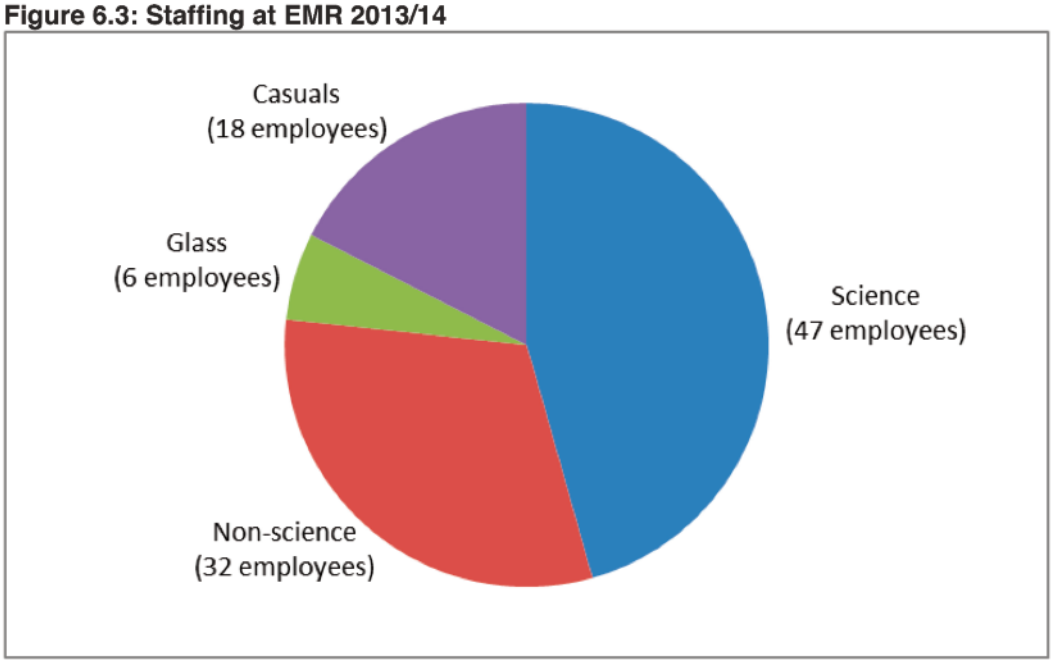
6.2.2 Employment

EMR has 85 members of permanent staff (2013/14) and employs a further 18 casual workers. As shown in Figure 6.3, just under half of permanent staff work in science related activities. We have estimated the number of full-time equivalent jobs (FTE) directly employed at EMR as 87 FTE[39].

In addition to direct employees, there are a further 6 Erasmus/Leonardo students, 2 internships, 4 visiting workers and 2 work placements. Therefore, in total there were 117 persons working at EMR in 2013/14.

[38] Income from commercial sources includes commercial income, IP income and HDC industry levy income.
[39] FTE numbers have been calculated assuming 10% of staff are employed on a part time basis and casual workers are employed for an average of 4 months a year.

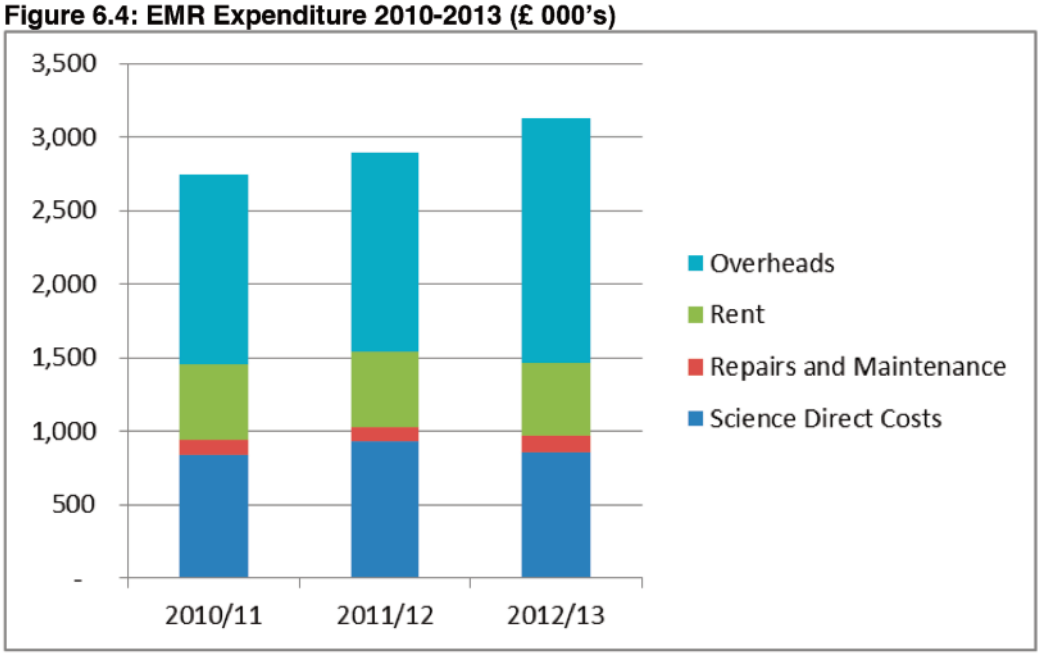
Figure 6.3: Staffing at EMR 2013/14



6.3 Indirect Impacts

Excluding salaries, EMR spent £3.124m in 2012/13. Overheads[40] represented 53%, Direct Science Costs 27% and repairs and rent 20% of expenditure as shown in Figure 6.4.

Figure 6.4: EMR Expenditure 2010-2013 (£ 000's)



[40] Which includes site costs, IT, PR and comms, professional fees, HR and training, accounts, cleaning, bank charges and irrecoverable vat.

This supplier expenditure supports output and employment amongst supplier industries, and their suppliers in turn. The extent of this impact can be estimated using the UK National Accounts published by ONS, estimating the level of expenditure required to support a FTE job in each supplier, and their knock-on expenditure.

In total for 2012/13, EMR's supplier expenditure (including construction) is estimated to **indirectly generate a total of £5.092m output for UK industries, supporting 61 jobs**.

6.4 Induced Impacts

Total salaries and staff costs paid by EMR were £1.94m in 2012/13. In addition, the salaries paid to staff working within the supply chain are estimated at £1.42m. In total, this £3.36m of direct and indirect salaries accrues to households and will then be spent on a profile of consumer goods and services, generating further economic activity in the UK. This forms the basis for EMR's induced impact.

Modelling this household income using an average consumer profile, indicates that the direct and indirect salaries will lead to increased spending of £2.97m and will support a further 26 jobs across the UK economy. While these induced impacts can be attributed to EMR, they will largely occur in sectors out-with the profile of direct and indirect industries, occurring instead in consumer industries such as retail and recreational services.

6.5 Summary of Operating Impacts

Table 6.1 summarises the direct, indirect and induced impacts of EMR in 2012/13 highlighting the 88 jobs and £5.085m of Gross Value Added (GVA) across the UK economy.

Table 6.1 Summary of EMR Operating Impacts

	Output (£000s)	Employment (jobs)	GVA (£000s)
Direct	£4,678		£1,939
Indirect	£5,092	61	£2,534
Induced	£2,966	26	£612
Total	**£12,736**	**88**	**£5,085**

6.6 Knowledge Exchange and Training impacts

EMR is contributing significantly to UK grower capabilities in management and husbandry by testing and proving new technologies and techniques. The results of this work are shared widely with industry, in association with the various research funding bodies, so that they can be adopted as required in the UK or internationally. EMR also undertakes practical training in many aspects of horticulture.

EMR undertakes extensive engagement with the public, trade and scientific partners. In 2013, this engagement included 14 radio and TV engagements, 22 newspaper and magazine mentions, 200 trade articles, 18 site visits, public open days and lectures, shows and career or trade events.

Scientific engagement included study tours, around 20 international conferences (3 where EMR gave keynote presentations) and the hosting of two international science meetings at EMR. EMR also signed a Memorandum of Understanding to work with Egyptian scientific partners in 2013.

There are currently 11 PhDs at EMR. Within the next 5 years there will be a funded programme of postgraduate research with partner universities to increase the number of research students.

These students are making a major contribution to the industry with horticultural consultees highlighting EMR's skills contribution as critical to future industry development.

7. Summary and Conclusions

This final section brings together a summary of the case studies, the impacts identified and the future potential contribution of EMR to productivity and policy objectives.

As stated in the introduction, the report does not cover all of EMR's achievements. Within the scope of this work a selection of case studies has been considered to give the best overview of EMR's work. The summary of impacts is, therefore, indicative of the scale of EMR impact, past, present and future.

7.1 Historic Cumulative Impacts of EMR

The **historic cumulative impacts of EMR's work in apple rootstocks and controlled storage are estimated at £8.9bn to the global economy**[41]. Both these innovations have been widely adopted globally and have provided the foundation for many other innovations. The timescales for these impacts are based on our assumptions about the lifetime of the innovations as follows:

- Apple rootstocks 1920-1960 £8.2bn
- Controlled atmoshpere storage 1930-1970 £700m

[41] This estimate does not net off the cost of the research which is unknown.

7.2 On-going Impacts of EMR

The on-going costs and benefits of EMR, based on a 10 year period[42] are set out in Table 7.1. The table shows £249.8m of benefits from which the costs of running EMR are subtracted to give a net impact of £216.6m.

For every £1 spent at EMR, at least £7.51 is returned to the UK economy. This represents the value for money of EMR's recent research. The assessment is conservative as all of EMR's annual spend is included even though we only consider a selection of impacts within the scope of this work.

Table 7.1 Summary of EMR Impacts over 10 years (base year 2013)

Section	Area of research	10 year present value (£m PV[43])
Apples	Post-harvest pathology	£9.98
Strawberries	Strawberry varieties	£16.63
	Import displacement	£13.64
	Reduced water usage (improved yield and reduced costs)	£107.57
	Reduced water usage (value of water)	£3.98
Pest and Diseases	Fruit tree red spider mite	£7.65
	Capsid bugs	£4.74
	Reducing pesticide use	£7.24
	Scab	£58.22
	Spotted Wing Drosophila	£8.22
Concept Pear Orchard	Concept pear orchard	£11.96
Total benefits		£249.82
Less estimated research costs		£33.27
Net benefits		£216.55
Value for money ratio		7.51

In addition, the operations of EMR support 88 jobs and £5.1m of Gross Value Added (GVA) in the economy per year.

Further information is included in Appendix 3 on the assumptions behind the present value calculations.

[42] In line with HM Treasury Guidance, costs and benefits are presented as present values over a 10 year period. Although the benefits of research come after the costs have been incurred, we have taken 10 years of both costs and benefits to assess the net impact. Research costs are assumed to be constant over the period.
[43] Costs and benefits are discounted at an annual rate of 3.5% in line with HM Treasury Guidance.

7.3 Future contribution of EMR

Section One outlined the scale of the UK Horticulture industry accounting for 175,000 ha of land, a farm gate value of £3.0bn a year, projected retail market value of £11.7bn by 2015 (fresh fruit and vegetables) and 93,000 permanent and seasonal workers in England alone.

Over the past 20 years, horticultural production has changed rapidly with self-sufficiency increasing for some crops but decreasing for others[44]. Levels of technology within the industry have risen rapidly leading to substantial productivity gains.

Recent price spikes for food, coupled with some uncertainties in the reliability of food chains, have led some retailers (the largest route to market for horticultural products) to develop plans to improve supply chain resilience, and to meet customer demands for British products wherever possible. Sainsbury's 2020 plan, for example, commits the company to increase the sale of British fruit to 50% of total by 2020 versus around 20% in 2012. This potentially represents a substantial increase in UK production.

Added to these drivers, climate change, water & energy efficiency, emerging pests and diseases, healthy eating, healthy ageing and food security objectives will create real challenges for the future of UK food production.

Within this context, a dynamic research base able to deliver to an increasingly innovative industry is essential. EMR represents the only centre in the UK able to offer whole systems approaches bringing together science and practice in horticulture. EMR's critical mass of skills, facilities, networks and expertise has the potential to contribute to many of these challenges.

It is clear from consultations that industry values the role of EMR and anticipates a strong future contribution in sustainable intensification. This will support industry growth, and assist with import substitution, exports of technology, expertise and products and potentially on-shoring economic activity back to the UK.

The future of UK horticulture is to be found in the application of innovative science and EMR is ideally placed to support it.

[44] NFU, Catalyst for Change, July 2012.

Appendix 1: Royalty method for valuing M9 Rootstocks

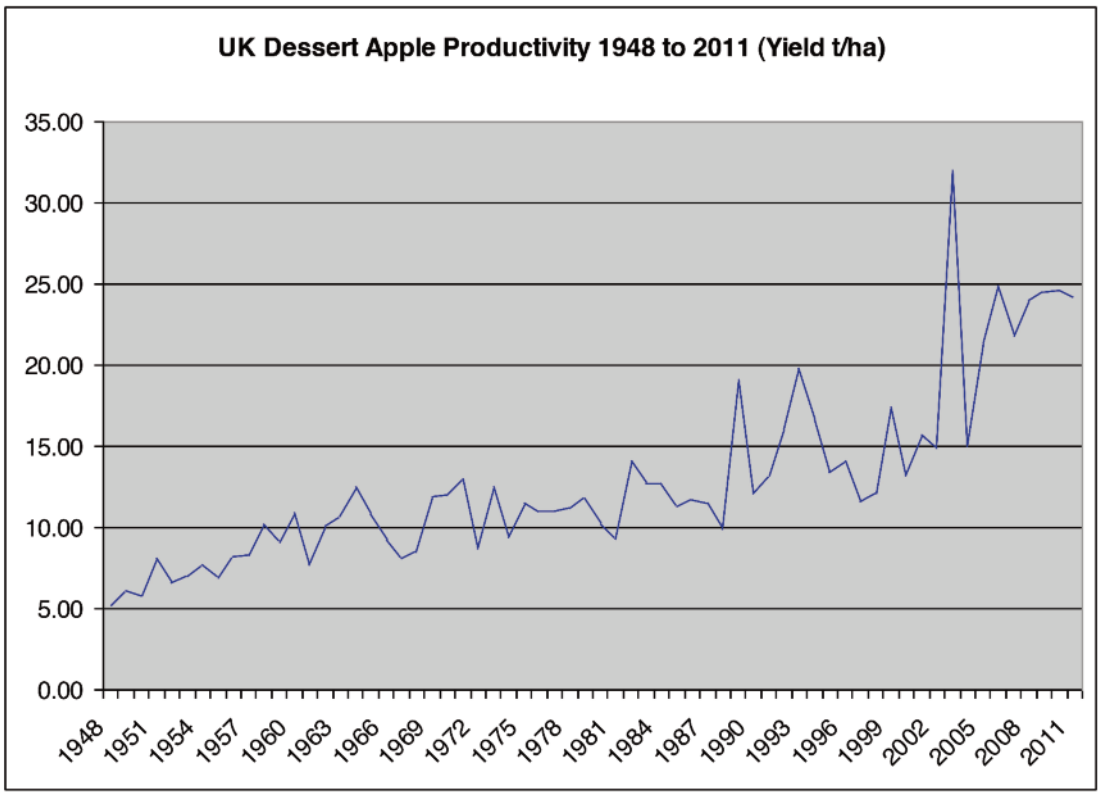
Source: Pennell (2013) EMR Centenary: 100 years Driving Productivity in Fruit Production

2000 to 2012 on average 13m hectares were occupied by apples in Europe (FAO Statistics).

Assuming an orchard life of 30 years some 39,000 ha would be replanted each season, requiring 19.5m rootstocks at a semi-intensive planting density of 500 trees per hectare rising to 89.7m at an intensive planting density of 2,200 per hectare.

Even at the conservative estimate that half these orchards used East Malling rootstocks, 9.8 to 44.9m East Malling rootstocks are used each year in Europe alone. If a nominal value of 1p is placed on each rootstock, £98,000-£449,000 could be attributed to East Malling rootstock research each year. At least this level of rootstock use has taken place over the last 50 years **resulting in a theoretical attribution of between £4.9m and £22.5m to value East Malling rootstock research to Europe alone**. If it had been possible to apply a more realistic Breeder Rights (Plant Patent) value of **10p per rootstock on this level of use up to £225m would have accrued to East Malling over the last 50 years**.

Appendix 2: Long term yield trends in the UK



Appendix 3: Summary of EMR's on-going impacts over 10 years

Section	Area of research	Type of Impact	Year 1	year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10 year NPV (£m)
Apples	Post-harvest pathology	Reduced losses	£1.20	£1.20	£1.20	£1.20	£1.20	£1.20	£1.20	£1.20	£1.20	£1.20	**£9.98**
Strawberries	Strawberry varieties	Improved traits	£2.00	£2.00	£2.00	£2.00	£2.00	£2.00	£2.00	£2.00	£2.00	£2.00	**£16.63**
	Import displacement	Reduced imports	£1.64	£1.64	£1.64	£1.64	£1.64	£1.64	£1.64	£1.64	£1.64	£1.64	**£13.64**
	Reduced water usage	Improved yield and cost savings	£3.80	£7.50	£15.10	£15.10	£15.10	£15.10	£15.10	£15.10	£15.10	£15.10	**£107.57**
		Value of water saving	£0.18	£0.36	£0.54	£0.54	£0.54	£0.54	£0.54	£0.54	£0.54	£0.54	**£3.98**
Pest and Diseases	Fruit tree red spider mite	Cost savings	£0.92	£0.92	£0.92	£0.92	£0.92	£0.92	£0.92	£0.92	£0.92	£0.92	**£7.65**
	Capsid bugs	Savings	£0.57	£0.57	£0.57	£0.57	£0.57	£0.57	£0.57	£0.57	£0.57	£0.57	**£4.74**
	Reducing pesticide use	Savings	£0.87	£0.87	£0.87	£0.87	£0.87	£0.87	£0.87	£0.87	£0.87	£0.87	**£7.24**
	Scab	Improved prices	£7.00	£7.00	£7.00	£7.00	£7.00	£7.00	£7.00	£7.00	£7.00	£7.00	**£58.22**
	Spotted Wing Drosophila	Avoided costs	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£11.60	**£8.22**
Concept pear orchard		Improved yield	£ -	£0.02	£0.26	£0.47	£1.25	£2.02	£2.51	£2.86	£3.04	£3.14	**£11.96**
Total benefits			£18.18	£22.08	£30.10	£30.31	£31.09	£31.86	£32.35	£32.70	£32.88	£44.58	**£249.82**
Cost of research			£4.00	£4.00	£4.00	£4.00	£4.00	£4.00	£4.00	£4.00	£4.00	£4.00	**£33.27**

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