Socio-Economic Impact of NIAB – Case Studies

Final Report

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September 2019

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Executive Summary

Brookdale Consulting was commissioned by NIAB to assess the impact of its activities in support of the UK economy. NIAB, formed in 1919, is a leading international crop science institute with a wide variety of near-market agricultural research.

The report focuses on a set of case studies agreed with NIAB's senior management. It does not cover all of NIAB's work.

The case studies have been selected to give the best overview of NIAB's current and future impacts including actual and potential impacts as follows:

- Variety and seed testing
- Potato agronomy
- Strawberry breeding
- Concept vineyard
- Pre-breeding for legumes

The UK agriculture industry is economically important. Total income from farming was £5.7 billion in 2017[1], with a labour force of 474,000 people on commercial holdings. The sector supports a further 408,000 jobs in food and drink manufacturing[2] and a food and drink grocery sector of over £87bn[3] in the UK alone.

The focus of NIAB's research is to improve the productivity, efficiency and resilience of agricultural and horticultural crop production.

NIAB has made long term contributions to the UK and international agriculture sector and this report highlights the scale of these impacts at the UK level.

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

- **On-going Impacts –** on-going impacts of NIAB's work represented here are estimated at £527M over a 10 year period (See Table 7.1). **For every £1 spent at NIAB, at least £17.60 is returned to the UK economy**.
- A key feature of the analysis is the high level of on-going actual impacts as well as future potential impacts. This reflects NIAB's unique interconnecting role between fundamental science and practical application.

NIAB's critical mass of skills, facilities, networks and expertise has a strong contribution to make to future challenges including climate change adaptation and resilience, sustainable intensification, productivity and food security.

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.

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[1] Defra 2018 Agriculture in the UK
[2] ONS Crown Copyright 2017 Business Register and Employment Survey
[3] Kantar Worldpanel 2019 GB data

1. Introduction

Brookdale Consulting was commissioned by NIAB to assess the impact of its research and development.

NIAB was established as a charitable trust in 1919 with the aim of improving UK crops through better crops and seed. From the outset, NIAB pioneered the development of the internationally recognised systems for variety testing and seed certification which have underpinned the growth and success of modern plant breeding and crop production.

More recently NIAB has successfully adapted and diversified from its UK government supported variety and seed testing work to become a leading international crop science institute with a wide variety of near-market agricultural research.

The UK agriculture industry is economically important. Total income from farming was £5.7 billion in 2017[4], with a labour force of 474,000 people on commercial holdings. The sector supports a further 408,000 jobs in food and drink manufacturing[5] and a food and drink grocery sector of over £87bn[6] in the UK alone.

In the face of climate change, growing populations, food security and the need to increase resource use efficiency there is a pressing need for research and development to meet these challenges. At the same time, a rapidly advancing knowledge base in crop genetics, data science, and precision agronomy is opening up major opportunities to deliver step-change improvements in the yield, climate resilience and resource-use efficiency of modern crop production sysyems. The case studies examined in this report demonstrate that NIAB is at the forefront of delivering these advances onto farm.

NIAB's work also highlights that the UK plant science base is internationally leading, and that there has been much progress in this area. There is also further biological potential to be exploited that can return substantial economic benefits to the UK economy.

The report focuses on a selection of five case studies which give a good overview of NIAB's research as follows:

- Variety and seed testing
- Potato agronomy
- Strawberry breeding
- Concept vineyard
- Pre-breeding for legumes

Within the case studies, there is a high level of on-going actual impacts as well as future potential impacts. This reflects NIAB's unique interconnecting role between fundamental science and practical application. The final section of the report summarise the impacts.

[4] Defra 2018 Agriculture in the UK
[5] ONS Crown Copyright 2017 Business Register and Employment Survey
[6] Kantar Worldpanel 2019 GB data

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

2. NIAB's contribution to variety and seed testing

NIAB's Unique Contribution	
Since its establishment 100 years ago, NIAB has pioneered the development of the internationally recognised plant variety and seed testing systems which have underpinned the successful evolution of modern plant breeding and crop production. Today, NIAB is the largest crop trialling organisation in the UK. Its activities encourage plant breeders to innovate through new varieties; growers to plant seeds, confident the label can be trusted; and industry to benefit from on-going productivity increases as genuinely improved varieties are delivered to the market.	
Net GVA attributable to NIAB at UK level over 10 years (NPV)	**£73,913,830**

Given increasing global population, the challenge of climate change, reduced chemical use and the necessity for sustainable production, there is a need for ongoing improvement in new varieties.

NIAB is the leading UK organisation providing independent testing of potential new varieties of agricultural crops as well as assurance of purity and origin of seeds through certification. It undertakes these roles on behalf of Government as part of the UK's plants and seeds regulatory regime, on behalf of the plant breeding industry and levy boards, as well as undertaking trials for private clients.

Together these plant variety and seed testing systems support continued investment in varietal improvement and help optimise productivity within the crop production sector.

NIABs work can be summarised as follows:

- **Distinctness Uniformity and Stability (DUS) trials** – NIAB runs DUS trials for major agricultural crops on behalf of UK Government[7]. This involves testing potential new varieties over 2 or more years to see if they are distinguishable from previous varieties. If found to be DUS, varieties may then be listed for plant breeder's rights thus protecting the intellectual property of the breeder and providing a mechanism for future royalty payments. NIAB is part of an international network which ensures that imported varieties meet the same standards.
- **Value for cultivation and use (VCU) trials** – NIAB runs VCU trials for major agricultural crops on behalf of clients in Government and industry. NIAB's work is focused on identifying enhanced performance such as in disease resistance, standing power and other traits. New varieties which are DUS and provide VCU can be added to the National List in the UK allowing them to be marketed here. These trials also provide the basis for the Recommended List (RL) of varieties produced by AHDB.
- **Seed certification** – NIAB provides seed certification services on behalf of Government for England and Wales. Certified seed is guaranteed to deliver the features associated with the variety and to meet recognised standards, e.g. for varietal purity, germination and freedom from impurities. In markets where no proper seed

[7] SASA performs a similar role to NIAB in Scotland for vegetables and potatoes and AFBI for grasses in Northern Ireland.

certification scheme exists breeders are reluctant to release their varieties and innovation may be stifled.

- **Contract trials and membership** – NIAB is the largest field trials operator in the UK and undertakes commercial trials on contract and its own membership-funded trials providing advice to its crop growing members.

Taken together, NIAB's work supports efficiency, ongoing productivity increases and supply chain security in UK and international agriculture. Impacts can be calculated in the following areas:

- Plant breeders are encouraged to invest and innovate knowing their varieties are independently assessed and their intellectual property is properly protected, and that seed supplies are well controlled and quality assured.
- Growers can be confident in purchasing and planting certified seeds knowing that the label can be trusted and that the variety shows a genuine improvement over historic varieties.
- Industry benefits from on-going productivity increases as genuinely improved varieties are delivered to the market

In addition to the above, Government and society at large are assured that the UK's food security is protected and consumers are assured of a plentiful supply of high quality food at reasonable prices.

The impacts on plant breeders, growers and overall industry are set out below.

2.1 Benefit to plant breeders

Our cost benefit analysis work for Defra[8] of the UK's plants and seeds regulatory regime established benefit to cost ratios of 9-31 depending on crop type. These ratios relate to the benefits perceived to result from regulation through trials etc, mainly in terms of royalties to plant breeders and an estimate of farm saved seed royalties. In the absence of regulation, it would be hard for plant breeders to capture this return on their investment. They would then be less likely to invest. These benefit to cost ratios can be applied to NIAB's spend in this area to assess the direct benefit.

Table 2.1 shows the estimated values to the UK economy for every £100k of NIAB spend on variety and seed testing for three groups of crops. This provides one measure of NIAB's impact in this area in safeguarding the royalties paid to plant breeders and the flow of innovation into new varieties in the UK and abroad.

Table 2.1: Benefit to cost ratios for different crop types based on 2012 figures

Crop type	NIAB spend on trials	Annual ratio of benefit to costs of UK regulation	Estimated value to the UK
Cereals	£100k	31	£3.1M

8 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/221064/pb13922-evidenceplan-plant-varieties-seeds.pdf

Oilseeds	£100k	9.2	£0.92M
Pulses	£100k	17.5	£1.75M
Total	£300k		£5.77M

Source: Brookdale Consulting work for Defra

2.2 Benefits to growers

Independent variety and seed testing and production of AHDB's Recommended List provide one central point of information collated by industry experts. In the absence of this system, growers may have to individually approach breeders and review multiple varieties, potentially conducting a number of tests themselves.

NIAB's work generates efficiency savings for growers during the variety selection process.

A market price estimate can be made for efficiency savings by growers during the selection process, based on the time saved or lost production that could have been undertaken during this same time[9]. Via consultations with agronomists, it is estimated that growers would take a half day per breeder to discuss available varieties. Growers would likely approach, at a minimum, the 4 largest breeders (who together have a majority market share). This equates to 2 days of lost production time per grower, which can be applied to industry production levels, to give an illustrative estimate for the gross value of their lost time. Given that Recommended Lists based on trials are widely used by 87% of growers while 90% of growers and agronomists rate the RL as an important source of information[10] a net figure, taking account of those that do not use the information is also provided.

Table 2.2: Time Savings during the Selection Process

Crop	Value of production in 2017	Estimated lost production without lists (efficiency saving)	
		Gross	Net
Wheat	£1,992M	£10.91M	£9.82M
Barley	£893M	£4.89M	£4.4M
Oilseed rape	£764M	£4.19M	£3.77M
Total	**£3,649M**	**£19.99M**	**£17.99M**

Source: Defra production figures and Brookdale estimates based on industry consultations

It should be noted that this represents a best estimate. However, production is not necessarily linear e.g. growers do not generate the same value each day. An alternative is to apply a time value of £100 per day to the two days multiplied by the 97,000 holdings growing crops in the UK (Defra). This gives a similar valuation of £19.4M gross or £17.5M net.

[9] We used this methodology previously to estimate the value of the RL for HGCA in 2010.
[10] AHDB 2018 Look Ahead Research Project

2.3 Productivity Improvements

The third area of impact is the delivery of on-going productivity improvements to industry through the orderly assessment of new varieties and reduction in the likelihood of crop failure due to selection of sub-optimal varieties from lack of knowledge. Our work in assessing the economic impact of plant breeding has developed a set of assumptions around on-going small productivity increases (1% per year) and avoidance of infrequent losses to disease (conservatively estimating 5% avoided losses in years 10 and 17). NIAB is one of several partners in the supply chain delivering these impacts so cannot take full credit for the impacts.

Table 2.3: Annual Productivity Improvements resulting from efficient delivery of new varieties

Crop	Value of production in 2017	Estimated annual productivity gains
Wheat	£1,992M	£19.92M
Barley	£893M	£8.93M
Oilseed rape	£764M	£7.64M
Total	**£3,649M**	**£36.49M**

3. NIAB's contribution to Strawberries

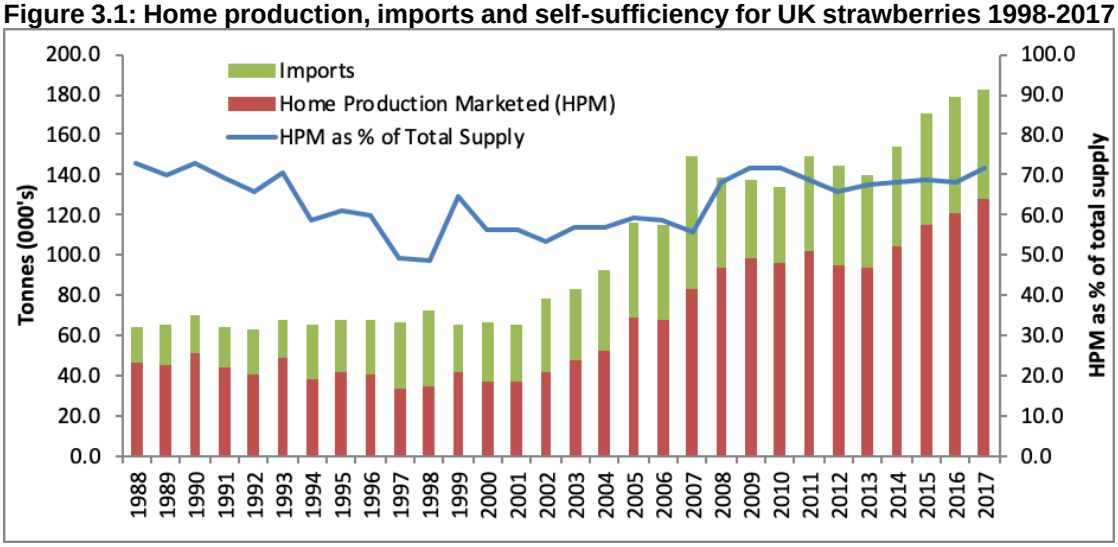
NIAB's Unique Contribution	
NIAB EMR is a leading breeder of strawberries having released 45 varieties to date, selling 85m plants in 2017/18 worth some £34M to nurseries and £1.6M of royalties to industry and NIAB. In recent years, NIAB's success has displaced dominant Dutch June-bearer varieties with UK ones.	
Net GVA attributable to NIAB at UK level over 10 years (NPV)	**£297,719,514**

3.1 UK Strawberry Market

According to Defra statistics, the farm gate production of strawberries was 128,000 tonnes worth £283M in 2018, more than double the 2005 level of production. At the same time, self-sufficiency has risen from 59% to 72% as shown in Figure 3.1.

Household consumption of soft fruit has more than doubled from an average of 20g in the 1970s to 66g per person in 2017. 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 1998-2017

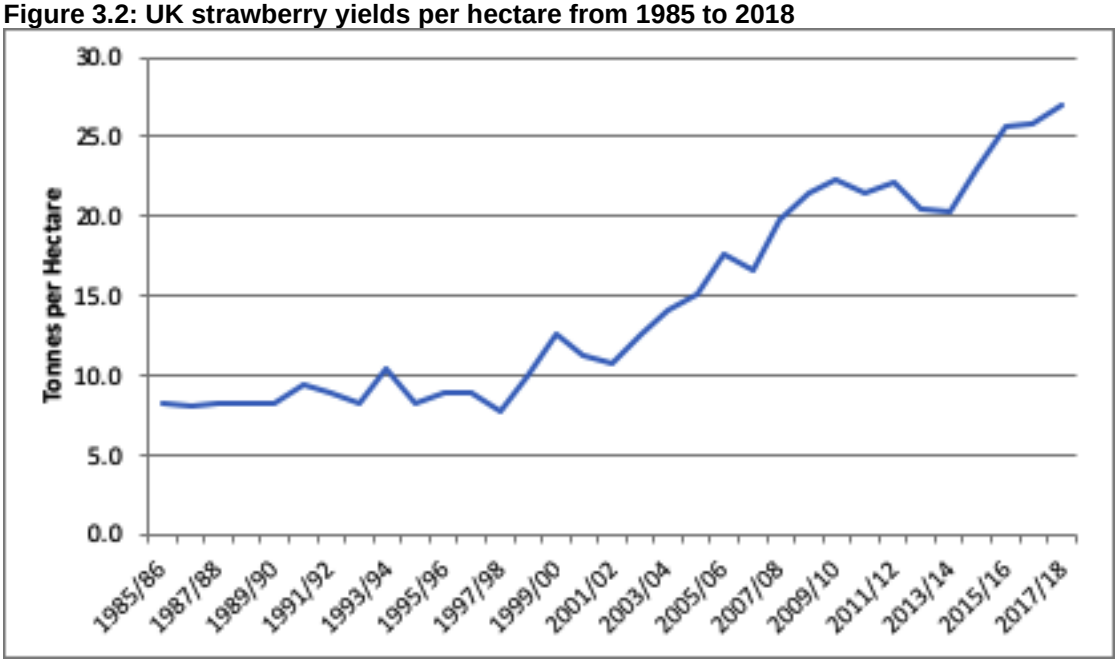


Source: Basic Horticulture Statistics, Defra, 2018

Consumer popularity has meant that alongside increased UK production, imports have increased from 17,600 tonnes in 1988 to 54,000 tonnes in 2017 to fulfil out of season demand.

The industry has responded to this increase in demand by improving productivity and NIAB EMR has had a key role in supporting this productivity growth alongside industry. Figure 3.2 shows the increase in yields achieved, to almost triple the level of the 1990s reaching 27 t/ha in 2018.

Figure 3.2: UK strawberry yields per hectare from 1985 to 2018



Source: Basic Horticulture Statistics, Defra, 2018

A key role of NIAB EMR has been to introduce high yielding new varieties with extended season of production, better picking efficiency and fruit quality and reduced waste, thus helping to displace imports. NIAB EMR is also working on integrated pest management and optimisation of water use. Alongside polytunnels, more efficient growing systems and improved management, these activities have been key in supporting productivity growth.

3.2 NIAB R&D in Strawberries

There are two types of strawberry plants:

- 'June-bearers' – 60% of the market - traditional varieties producing a predictable crop in the natural season (May-June) as well as being used for forced early production and programmed cropping.
- 'Ever-bearers' – 40% of the market - continuous fruit production, traditionally cropped from mid-July to October, although production and fruit quality is less predictable from season to season.

Since the 1970s, Dutch varieties such as Elsanta and Sonata have traditionally dominated the UK retail market for June-bearers. That has now changed with NIAB EMR's high performing variety Malling™ Centenary now accounting for approximately 60-70% of the June-bearer market in the UK and on-going expansion on the continent. This has pushed out Sonata and Elsanta whose estimated UK market shares are now in the region of 5-10% combined.

NIAB's success relates to its multi-disciplinary research combining knowledge of yield and quality, its development of molecular markers, understanding of pest and disease control and

its focus on reducing growing costs including labour. Comparative trials between Malling™ Centenary and Elsanta have demonstrated the following benefits[11]:

- Fruit quality – exceeding Elsanta in uniformity, skin firmness, and appearance
- Fruiting – four days ahead of Elsanta in the UK
- Total yield – 27.1t/ha slightly less than Elsanta at 27.4t/ha
- Waste – less than 1% compared to Elsanta at 15%
- Class 1 yield per plant – 60g- 285g ahead of Elsanta.
- Class 1 fruit as proportion of yield – about 10% ahead of Elsanta
- Picking costs - £0.43/kg compared to Elsanta at £0.56/kg

Malling™ Centenary's simple truss structure and large sized fruit are the key aspects contributing to its high class 1 yield and reduced picking costs.

Malling™ Centenary was selected in 2006 and commercially released in 2013. NIAB EMR have new varieties in the pipeline which will provide further benefits. For example, Malling™ Allure is being released for commercial production this year (2019) and demonstrates the positive fruit quality and picking efficiency attributes of Malling™ Centenary but with slightly improved disease resistance and a steadier production profile. Malling™ Champion is a variety for the everbearer market, again demonstrating the attributes of Malling™ Centenary but for an extended season of production and with better disease resistance. In addition, there are other lines within the NIAB EMR pipeline that are producing exceptional Class 1 yields of high quality fruit; suggesting further large productivity increases are possible in the near future[12].

Table 3.1 sets out the financial impact of Malling™ Centenary compared to Elsanta on a tunnelled, substrate system. It shows an improvement in Gross Margin of £17,464 per ha. Given Malling™ Centenary's dominance (65%) in the June-bearer market which is around 60% of strawberry production, this enhanced benefit could be worth £32.2M per year to UK industry.[13]

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

	Typical previous high performing variety £ per Ha		NIAB EMR high performing variety £ per Ha	
Yield	27.4t per ha @ £3,610/t at farmgate.	£98,914	27.1t per ha @ £3,610/t at farmgate.	£97,831
Less wastage	15%	£14,837	1%	£978[5]
Total output		**£84,077**		**£96,853**
Planting		4,190		4,190
Structures		9,190		9,190
Fertilisers/sprays		1,777		1,777
Fieldwork		4,504		4,504

[11] A combination of NIAB trials and commercial grower results from 60 day cropping.
[12] The impact model includes a further 20% estimated improvement from year 5.
[13] Total area of 4,728 ha in 2018 * 60% * 65% = 1,844 ha * £17,464 = £32.2M assuming prices are unchanged.

Harvesting		20,194		15,506[14]
Grading/packing		6,440		6,440
Packaging		9,085		9,085
Transport		4,370		4,370
Commission/Levies		7,475		7,475
Total Variable Costs		**£67,225**		**£62,537**
Gross Margin		**£16,852**		**£34,316**

Source: John Nix PocketBook 2019 49th Edition plus industry sources.

NIAB's work is funded from both public and private sources. The annual income from this partnership is in the region of £570k per year. NIABs work and its future potential has been underpinned by fundamental research.

[14] Waste was found to be less than 1% compared to 15% with Elsanta while picking costs were found to be 23% lower for Malling™ Centenary in a commercial trial.

4. NIAB's contribution to Vineyards

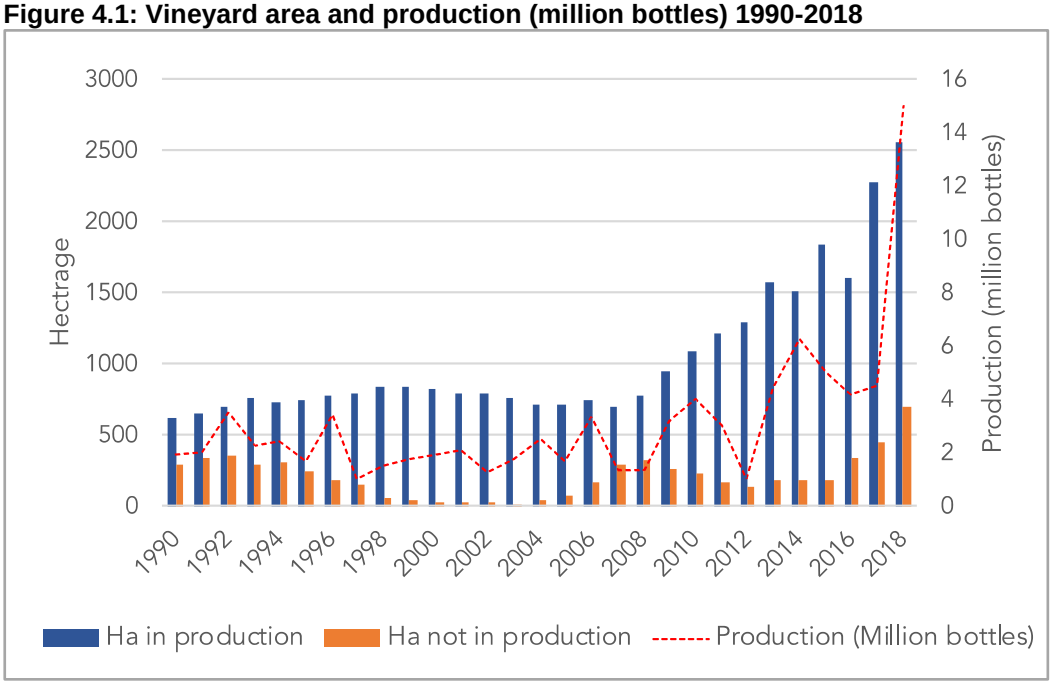
NIAB's Unique Contribution	
NIAB EMR has been involved in the wine industry since 2015 when it recognised the rapid growth in the sector and a need for R&D to support this growth as part of its novel crops research. A research vineyard of one hectare was planted in 2015. Then in 2016 a consortium of NIAB EMR and leading UK vineyards was established to fund and co-ordinate R&D support to the sector.	
Net GVA attributable to NIAB at UK level over 10 years (NPV)	**£101,169,693**

4.1 UK Wine Production

According to WineGB, the UK wine growing area has doubled since 2008 to reach 1,612 ha in 2016, producing over 31,000 hectolitres (hl) of wine, down from a peak of 47,400 hl in 2014 as shown in Figure 4.1. The sector's performance is strongly influenced by weather conditions, with 2012 being a poor year due to frosts and 2014 being a boom year due to warm conditions. Beyond this official data, the UK area continues to expand rapidly according to WineGB; with the area reaching 2,500 hectares in 2017 and a further 1.7M vines planted in 2018.

Alongside this rapid growth in area, the number of vineyards has also risen to more than 500 - up from 416 in 2008. Many vineyards are also wineries with the number of UK wineries rising to 135 in 2016.

Figure 4.1: Vineyard area and production (million bottles) 1990-2018

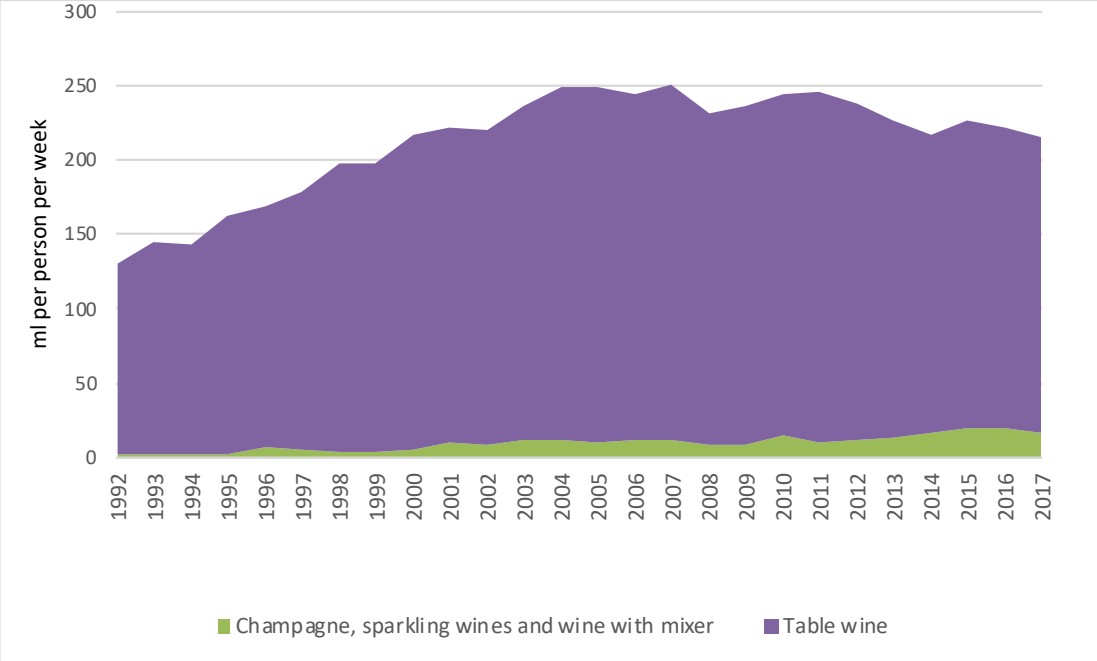


Source: NIAB EMR, Lecourt Julien, 2019

The UK wine industry is a success story of rapid growth and high quality production. WineGB estimates current retail sales of £130M per year with an aspiration to grow to £500M within 3 years and £1 billion by 2040.

UK household consumption of wine and sparkling wine (including champagne) has risen from 130 ml per person per week to over 200 in 2017, though this is down from a peak of 250 in 2007. Sparkling wine consumption has doubled, though down from a peak of 20ml per person per week.

Figure 4.2: Household consumption of wine and sparkling wine 1992-2016



Source: Adjusted National Food Survey data 1974 to 2000, Expenditure and Food Survey 2001-02 to 2007 and Living Costs and Food Survey 2008 onwards

The UK is a major importer of wines primarily from France, Italy and Australia/New Zealand. As the indigenous industry has grown, the UK has increased its exports of high quality wines. WineGB expects that the US will remain its largest export market followed by Japan and Australia, with exports of wines from the UK expected to reach £350M by 2040.

4.2 NIAB R&D in viticulture

NIAB's research covers resource efficiency, genetic improvement and pest and disease control. The new research vineyard provides a platform to test solutions and de-risk them for UK growers. NIAB's growing capability in this area is attracting increasing interest from abroad. One example of this is NIAB's leading role in a Horizon 2020 EU research project to improve weed control and reduce chemical use.

A key challenge for the UK industry is that despite the rapid growth of the domestic wine sector, the average yield is only 4.4-5.9 t/ha as shown in Table 4.1. This yield is well below that achieved in France's Champagne region where a harvest yield of 10.4 t/ha is the norm rising as high as 15.5 t/ha[15].

Table 4.1 UK Vineyard yields in the 2017 season (tonnes per ha)

Variety	Not frosted	Frosted	%
Chardonnay	5.1	2.5	-49.7
Pinot noir	4.7	2.7	-42.6
Madeleine angevine	6.4	4.1	-36.8
Pinot Meunier	5.4	3.7	-31.9
Seyval blanc	7.1	5.7	-19.7
Reichensteiner	4.6	4.0	-12.0
Rondo	9.3	8.4	-9.1
Bacchus	4.3	4.0	-7.9
UK Average	**5.9**	**4.4**	**-25.0**

Source: NIAB EMR, modified from Skelton's UK harvest report 2017.

NIAB EMR's research vineyard produced a yield of 8 t/ha in its first year. This yield would be expected to rise as the vineyard matures with the aim of producing 12 t/ha. This provides a demonstration to the UK industry of what is possible under conditions here. The key to increasing yields is management and attention to detail. Imaging technology is increasingly being used in management. As the UK industry adopts NIAB's methods its productivity will increase.

Table 4.2 shows the potential financial impact of improved productivity on a typical UK sparkling wine producer covering both vineyard and winery output. Vineyard gross margins could potentially increase by £7,400 per ha and winery gross margins by £6,350 per ha.

[15] Appellation d'origine contrôlée in Champagne requires yields of no more than 15.5 tonnes per ha based on high-density planting of vines (8,000 per hectare). This improves ripening and quality - see www.champagne.fr

Table 4.2 Financial effect on gross margin of adopting NIAB research vineyard based on sparkling wine

	Typical UK system £ per Ha		NIAB research vineyard £ per Ha	
Grape Yield	5t per ha @ £1,500-£2,500/t delivered to the winery.	£7,500-£12,500	12t per ha @ £1,500-£2,500/t delivered to the winery	18,000-30,000
Vineyard output (mid-point of range)		**£10,000**		**£24,000**
Establishment	Double Guyot 3,000-5,000 vines per ha @£27,500[16] spread over 28 years	1,000	Double Guyot 8,000 vines per ha @£41,250[17] spread over 28 years	1,473
Annual costs	Materials £1,500 Labour (growing) £6,250 Harvesting £1,600	9,350	Assume 1.5 times for materials and growing labour and 2.4 times for harvesting	15,465
Variable Costs		**£10,350**		**£16,938**
Vineyard Gross Margin		**£-350**		**£7,062**
Wine Yield	675-800 bottles/t = 3,375-4,000 bottles per ha @ £7.73 per bottle ex winery[18]	£26,089-£30,920	675-800 bottles/t = 8,100-9,600 bottles per ha @ £7.73	62,613-£74,208
Winery Output (mid-point of range)		**£28,504**		**£68,410**
Bottling etc	£6.50 per bottle	23,968	£6.50 per bottle	57,524
Gross Margin before storage costs		**£4,535**		**£10,885**

Source: John Nix PocketBook 2019 49th Edition plus industry sources.

Applying the financial impact to the UK area in 2017 (2,500 ha) and assuming 60% of UK production is for sparkling wine would suggest 1,500 ha potentially benefiting and a maximum impact of £10.6M per year at vineyard gate and a further £9.5M at wineries before storage costs. This £20M is the maximum potential annual impact. Recognising that not all growers will adopt the improvements assumptions have been made about gradual adoption up to 80% of sparkling wine producers.

As climate change increases temperatures, it is anticipated that around 34,000 hectares of land in South East England could become suitable for wine production. This, combined with strong market growth suggests that there is potential to grow the UK industry further. For this reason, the economic model includes an annual increase in area of 10%.

[16] Materials £15,000 and labour £12,500.
[17] Higher density vineyard so assume establishment is 1.5 times the lower density one.
[18] Assume retail price of £20 less VAT = £16.67 less retailer margin of 30% = £11.67 less wholesaler margin of 10% = £10.50 less duty of £2.77 = 7.73

5. NIAB's contribution to Potatoes

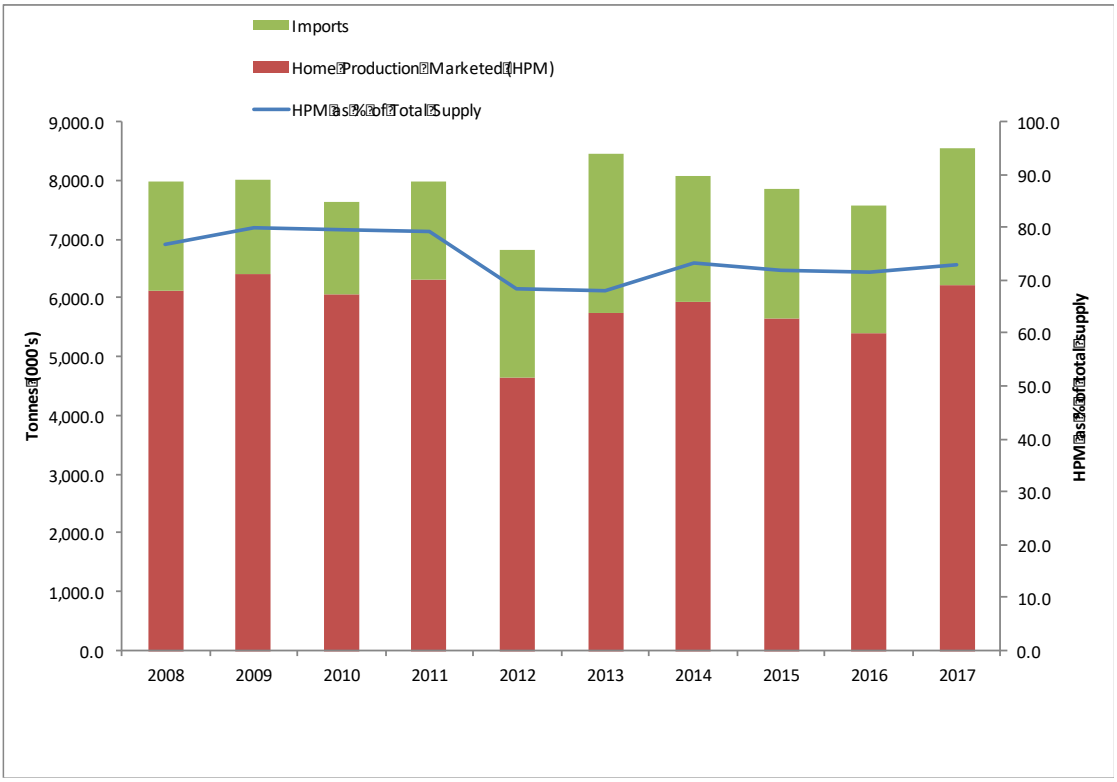
NIAB's Unique Contribution	
NIAB CUF is a leader in applied potato research focused on three areas as follows: • Irrigation scheduling model • Potato yield model • Agronomic and varietal advice Major industry players see NIAB CUF as the 'go to' people for potato production advice, with demonstrable benefits for the industry in terms of improved productivity, cost savings and resource-use efficiency.	
Net GVA attributable to NIAB at UK level over 10 years (NPV)	**£25,556,928**

5.1 UK Potato Market

According to Defra statistics, the farm gate production of potatoes was 6.2M tonnes worth £897M in 2017 (provisional figures). This is a similar level of production to 2008, however production has fluctuated over the period, mainly due to weather. The UK meets just over 70% of its requirements for potatoes with imports providing the remainder.

Long term household consumption of fresh potatoes has reduced by 70% from an average of 1,318g per week in 1974 to 401g per person in 2017. This is due to the growth of alternatives such as pasta and rice. However, processed potato consumption (excluding takeaway chips) has increased threefold to 207g per person with a much higher value than fresh potatoes, driving processing activities which are important to the UK economy.

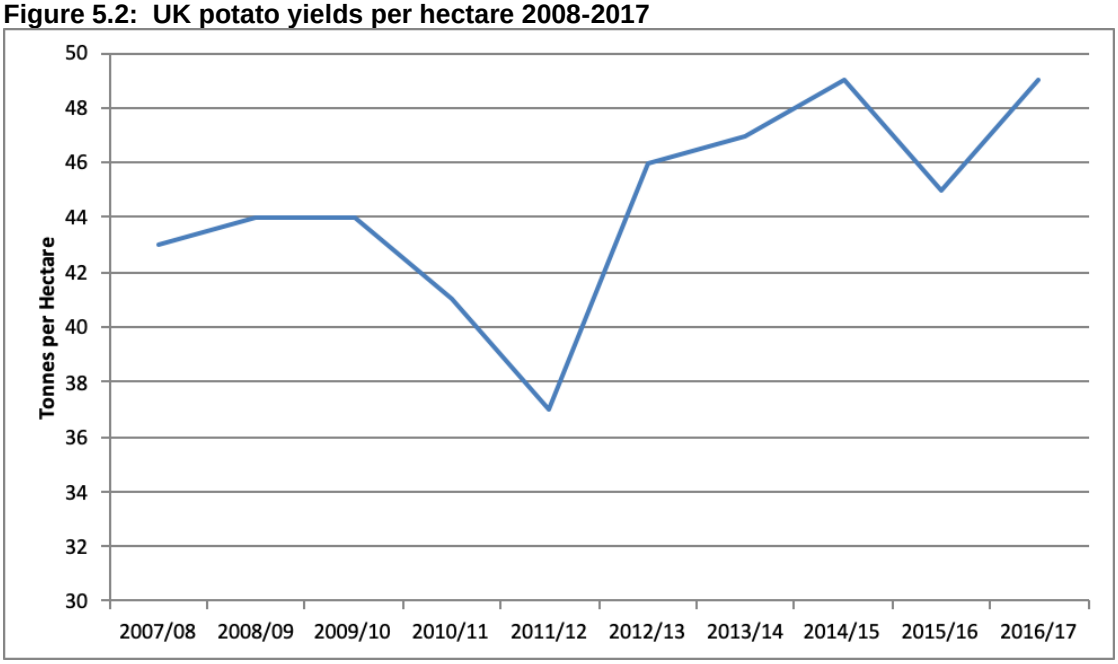
Figure 5.1: Home production, imports and self-sufficiency for UK potatoes 2008-2017



Source: Basic Horticulture Statistics, Defra, 2018

The industry has increased its productivity with an overall trend of increased yields despite climatic challenges and a move towards quality rather than simply volume. NIAB CUF has had a key role in supporting this productivity growth alongside industry. Figure 5.2 shows the increase in yields achieved, from around 43 t/ha in 2007/08 to 49 in 2016/17.

Figure 5.2: UK potato yields per hectare 2008-2017



Source: Defra, 2018

5.2 NIAB R&D in potatoes

NIAB CUF's three research areas are outlined below followed by three industry case studies providing examples of its impact. The case studies are presented anonymously to preserve commercial confidentiality.

5.2.1 Irrigation Scheduling Model

NIAB CUF has developed an irrigation scheduling model that combines meteorological data, canopy data, variety and soil type data to estimate irrigation requirements. Growers provide the information weekly to NIAB via a manual grid or app. NIAB CUF has offered this service for many years with the aim of helping growers to optimise yield and minimise water use.

It is estimated that around half of the UK's 145,000 ha of potatoes are irrigated in any given year. Many growers do not have enough water. As climate change affects the UK, the demand for irrigation scheduling is likely to increase to improve water use efficiency. As well as optimising crop growth, the model can help control common scab, to which popular varieties such as Maris Piper, are susceptible.

NIAB CUF has around 3,000 ha of potatoes within its irrigation scheduling service.

5.2.2 Potato Yield Model

NIAB CUF has also developed a potato yield model that combines location, planting date, variety type, emergence and canopy data to forecast final yield and size distribution along with the optimum desiccation date. By collecting this information over a long time period, NIAB is able to fine tune the model to improve its accuracy. Growers provide the data via app as well as information from a sample dig to NIAB. The model allows growers to forecast early on in the season whether their crops are likely to achieve the required size distribution and overall yield for their contracted requirements. If a shortfall is suspected, they can purchase additional tonnage on contract before prices rise (see case study Company 1 below).

NIAB CUF has around 500 client crops benefiting directly from the model. As well as UK growers, the model is used in North America. Growers tend to apply the model to a proportion of their area, so the actual area benefitting from the model is much larger than the 500 crops it is directly applied to.

5.2.3 Agronomic and varietal advice

A well as specific models, NIAB CUF provides agronomic advice to growers, helps with specific problem solving and runs trials on varieties to assess performance. Trials can be particularly helpful for growers looking to introduce new varieties as the stakes are high (see case study Company 2 below). This advice draws on NIAB CUF's many years' experience in potato growing.

Company 1

Company 1 is a major grower of potatoes supplying 85,000 tonnes per year to processors through its 30 growers. Over the past 9 years it has seen a 9.2% increase in yield per hectare – approximately 1% per year due to NIAB CUF help and advice focusing on three factors:

- yield response to nitrogen and water
- irrigation scheduling
- variety selection and variety specific agronomy

This yield increase has allowed the company to fulfil its contracts from fewer hectares with significant cost reductions in land rental and levies[19] as well as associated carbon and water reductions. Taking the 1% increase cumulatively over the 9 years would mean a saving of £778k in total or £86.5k per year.

In addition, Company 1 has benefited from NIAB CUF's yield model predicting the likely harvest yields for the whole crop based on samples across 20% of the crop early on in the season when prices tend to be fairly static. The yield prediction has allowed the company to place contracts for purchasing additional tonnage to fulfil contracts or to buy tonnage that can be sold on at a profit later in the season when the prices rise due to shortage. The company estimates £50/t benefit on around 2,000 tonnes per year giving a total impact of £100k per year.

Company 2

Company 2 supplies 350,000 tonnes of potatoes annually to supermarkets for fresh consumption, to processors for French fries and for seed (UK and export). NIAB is seen as the 'go to' institute for potatoes, being the only agronomic potato research in the UK. The company uses NIAB's yield and irrigation models on a proportion of its area. The key benefit of NIAB's research is in de-risking new varieties. The company invests in the breeding of new varieties but there is always a risk of crop failure when they are introduced commercially. Using NIAB trials allows the company to develop agronomic approaches for new varieties before they are introduced thus avoiding potential crop failures. Assuming a new variety is introduced every 2.5 years on average with 500t of seed planted over 200ha gives a potential saving of £350k per year versus the risk of crop failure[20].

Company 3

Company 3 is a major grower, packer and processor of potatoes supplying the major retailers with fresh and frozen products. NIAB CUF are seen as the 'go to people for potatoes'. As well as use of NIAB's yield model the company has regular bespoke projects to address specific issues relating to its production. One example is a project to address high levels of bruising in some varieties. Up to 50% bruising has been found and NIAB's hands-on research has been able to reduce levels of bruising by up to half. Prior to the project, two varieties accounting for 10% of output were seeing 50% wastage worth £3.5M. Reducing this wastage by half has saved the company £1.75M, though annual variability can reduce the level of saving suggesting that an annual benefit of £1M would be a more conservative estimate.

[19] Land rental ranges from £600-£1,200/ha, figure used £1,000. Levies £42.62/ha. Source John Nix PocketBook 2019 49th Edition. Area of potatoes estimated at 1,417ha down from 1,545 based on yield increasing from 55 to 60t/ha over the period.

[20] 200ha @ 50t/ha versus 25t/ha if the crop fails at £175/t= £875k every 2.5 years or £350k/year.

6. NIAB's contribution to pre-breeding

NIAB's Unique Contribution	
NIAB is a leader in pre-breeding research whereby new genetic material is introduced into pre-breeding lines that plant breeders can use to develop new varieties with beneficial characteristics. Pre-breeding provides a vital link between the discoveries and advances taking place in fundamental plant science and the application of that new knowledge in commercial breeding programmes.	
Net GVA attributable to NIAB at UK level over 10 years (NPV)	**£28,492,128**

NIAB's work in pre-breeding began in 2005 using material from elsewhere to provide useful wheat crosses for plant breeders. As the work developed, NIAB started to use its own material for pre-breeding and that work is maturing now with advanced pre-breeding lines with superior characteristics for use by plant breeders in the UK and abroad. NIAB's work is part of the UK's 'Designing Future Wheat' programme and complements the work of other institutes such as the John Innes Centre. The resultant wheats are known as synthetic wheats.

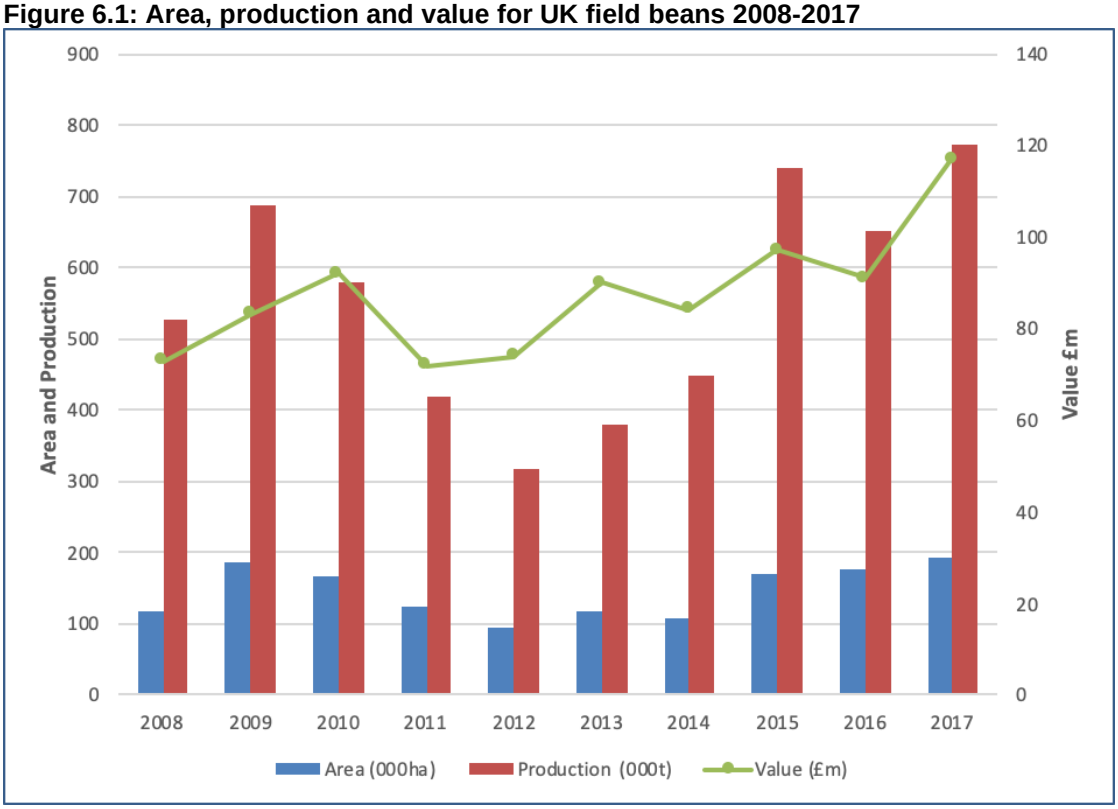
The aim of pre-breeding is to introduce new genetic diversity to deliver beneficial characteristics. This can be done by recreating modern wheat from its original ancestors. NIAB is using ancient wild grass species (Aegilops tauschii) and durum wheat (Triticum durum) as parents to recreate modern wheat. These may be drawn from seed banks or other sources. These novel lines are then crossed to UK adapted varieties on a large scale. The process is very technically demanding and intensive. It is unlikely that any one plant breeder would do this on their own.

Pre-breeding has helped to deliver on-going productivity increases in wheat and other crop types. However, there are other smaller crops that could benefit from the same attention to improvement and field beans is one of them. [DW1]

6.1 UK Field Bean Market

According to Defra statistics, the farm gate production of beans was 771,000 tonnes worth £117M in 2017 (provisional figures). The volume harvested has fluctuated over the period while value shows an overall increase. However, volumes are still relatively small at less than 1M tonnes nationally (Figure 6.1).

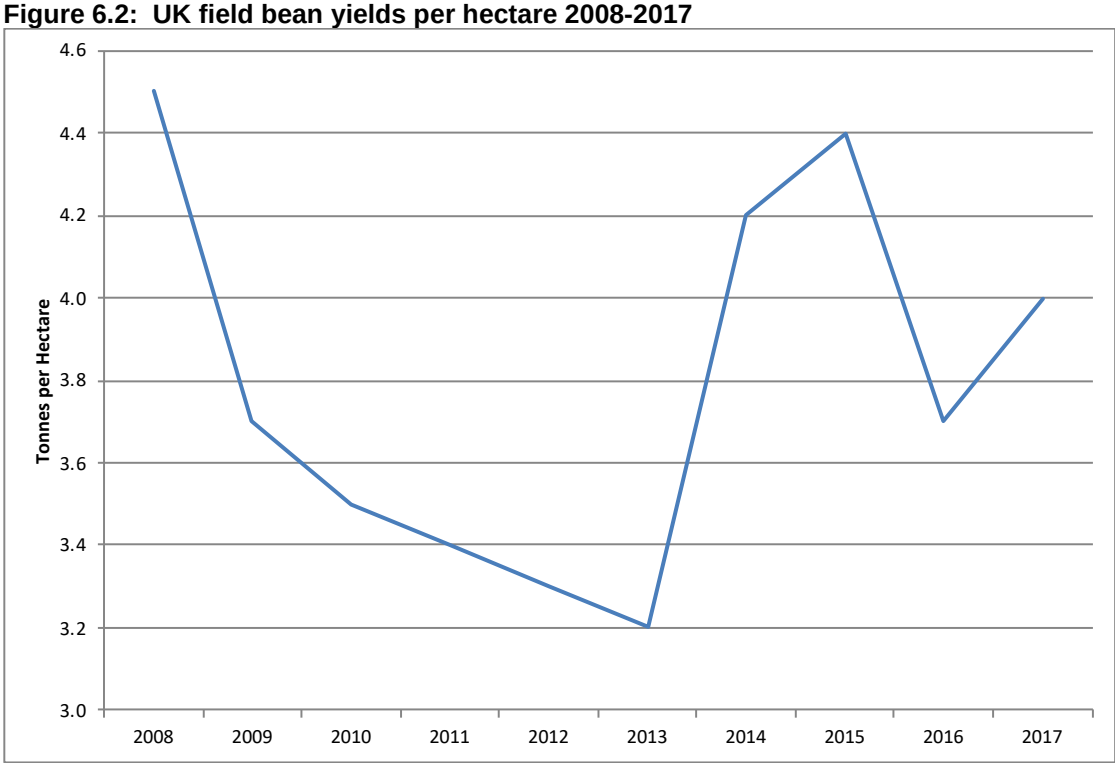
Figure 6.1: Area, production and value for UK field beans 2008-2017



Source: Defra 2018

Figure 6.2 shows the yield performance of beans in the UK over the past 10 years. Yields have fluctuated between 3.2 t/ha to 4.5 t/ha. Whilst the variability in yield may be largely due to climatic factors, the relatively low yield makes the crop commercially unattractive to growers. The average of 3.8t/ha over the period compares with wheat yields of 7.9t/ha, more than twice the level. The low level of yield is due to a lack of investment in plant breeding focused on performance improvement.

Figure 6.2: UK field bean yields per hectare 2008-2017



Source: Defra 2018

A lack of investment in beans means that it has not benefited from genetic improvement to enhance performance. This creates something of a catch twenty-two. Beans is a potentially valuable break crop with soil organic matter and nitrogen benefits, potential to displace imports of soya and to improve the sustainability of UK agricultural production. However, financial returns to plant breeders are likely to be very long term and small compared to crops such as wheat. There is potential to improve disease resistance, yield and protein content to compete with imported soya and substantially grow the volume of the crop in the UK. NIAB sees an opportunity to improve the performance of field beans through pre-breeding. The impact of this work will be in improved productivity delivering enhanced returns to UK producers.

The UK imports annually 3.8M tonnes[21] of soya. Whilst some soya is grown[22] in the southern UK, it cannot be grown further north. The average gross margin for field beans in the UK is £471/ha compared to £791 for wheat or £715 for oilseed rape[23]. PGRO estimates that in

[21] EFECA (2018) UK Roundtable on Sustainable Soya: Baseline study. The figure includes 0.7M tonnes embedded in imported products.
[22] John Nix Pocketbook 2019 49th Edition estimates 6,000 tonnes in 2018.
[23] John Nix Pocketbook 2019 49th Edition - average of winter and spring beans.

addition to this, the value of nitrogen fixed by field beans is worth £33/ha. By providing pre-breeding material to plant breeders, there is potential to enhance the performance of field bean varieties.

NIAB estimates that improved yield performance of 0.5% per year and improved crop quality resulting in higher prices of £10/t could be possible from a 3 year research programme costing £0.5m. This would deliver additional income, by year 10, of £8.9M per year to UK farmers. It would also provide an alternative to crops such as oilseed rape which have suffered from the withdrawal of chemical pesticides.

7. Summary and Conclusions

This final section brings together a summary of the case studies along with the impacts identified that highlight NIAB's contribution to UK agricultural productivity.

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

7.1 On-going Impacts of NIAB

The on-going costs and benefits of NIAB, based on a 10 year period[24] are set out in Table 7.1. The table shows £527M of gross benefits and an estimate of the costs of NIAB activities at £30M – this assumes the case studies represent around 15% of all NIAB activity.

For every £1 spent at NIAB, at least £17.60 is returned to the UK economy. This represents the value for money of NIAB's research.

Table 7.1 Summary of NIAB Impacts over 10 years (base year 2018)

Case Study	Actual or Potential	Total GVA over 10 years (£)	Attribution to NIAB	Net GVA attributable to NIAB at UK level over 10 years (NPV)
Variety & Seed Testing	Actual	£147,827,660	50%[25]	£73,913,830
Strawberries	Actual	£297,719,514	100%	£297,719,514
Vineyards	Potential	£101,169,693	100%	£101,169,693
Potatoes	Actual	£25,556,928	100%	£25,556,928
Pre-breeding	Potential	£47,486,880	60%[26]	£28,492,128
Total			**(a)**	**£526,852,093**
Research Costs			**(b)**	**£29,939,779**
Return on Investment			**(a)/(b)**	**£17.60**
Made up of:				
Actual impacts				£397,190,272
Potential impacts				£129,661,821

Further information is included in Appendix 1 on the assumptions behind the present value calculations.

[24] In line with HM Treasury Guidance, costs and benefits are given 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.
[25] Taking account of contributions from plant breeders, other institutes and industry.
[26] Shared with plant breeders.

Appendix 1: Summary of NIAB's on-going impacts over 10 years

Case Study			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	NPV	Attribution to NIAB	NPV
Variety & Seed Testing	Grower time savings	£ -	£ -	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 17,775,000	£ 147,827,660	50%	£ 73,913,830
Strawberries	Gross Margin benefit	£ -	£ -	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 32,202,219*	*£ 267,813,145*	100%	
	Benefit from further new varietie	£ -	£ -	*£ -*	*£ -*	*£ -*	*£ -*	*£ 6,440,444*	*£ 6,440,444*	*£ 6,440,444*	*£ 6,440,444*	*£ 6,440,444*	*£ 6,440,444*	*£ 34,318,246*	100%	
	Total Strawberry benefit	£ -	£ -	£ 32,202,219	£ 32,202,219	£ 32,202,219	£ 32,202,219	£ 38,642,663	£ 38,642,663	£ 38,642,663	£ 38,642,663	£ 38,642,663	£ 38,642,663	£ 297,719,514	100%	£297,719,514
Vineyards	Vineyard gross margin benefit	£ -	£ -	£ 2,220,000	£ 4,884,000	£ 8,058,600	£ 11,819,280	£ 13,001,208	£ 14,301,329	£ 15,731,462	£ 17,304,608	£ 19,035,069	£ 20,938,575	£ 101,169,693	100%	£101,169,693
Potatoes	Annual benefit after scale up	£ 3,073,000	£ -	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 3,073,000	£ 25,556,928	100%	£ 25,556,928
Pre-breeding	Annual Benefit to yield	£ -	£ -	£ -	£ -	£ -	£ 3,946,712	£ 8,066,847	£ 8,240,271	£ 8,413,694	£ 8,587,118	£ 8,760,541	£ 8,933,965	£ 47,486,880	60%	£ 28,492,128
Total NPV														£ 619,760,675		£526,852,093
Costs of NIAB	From annual accounts	£ 24,000,000	15%	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£ 3,600,000	£29,939,779		£29,939,779
Return on investment	For every £1 spent the return to the UK economy is:															£ 17.60

Annual benefits are based on in-depth consultations with NIAB staff and/or industry to establish specific impacts. Established industry sources have been used for gross margins and other assumptions.

Benefits are presented as gross value added (GVA), the Government's preferred measure of economic activity.

Two estimates were used for costs. 1. Consultees were asked to estimate implementation costs. These estimates tended to relate to direct costs only. 2. A proportion of NIAB's annual running costs were used so that full overheads and equipment costs were included. On the basis that the five case studies represent around 15% of NIAB's annual activity, 15% of annual costs were used taken from annual accounts. The 15% figure was based on discussion with NIAB's senior management team.

Net Present Value is used with a discount rate of 3.5% in line with HM Treasury Green Book guidance.