Endocrine disruptors – collation impacts across all sectors to give clear messages on impacts of changing availability on farmers and production

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EXECUTIVE SUMMARY

Under the revision of the pesticide approvals legislation and the implementation of European Union Plant Protection Products (PPP) Regulation (1107/2009) there has been a move from a risk to hazard based assessment criteria for the approvals of pesticide active substances. As part of this move it was identified that endocrine disrupting active substances should be classified as a hazard. However, the definition of endocrine disruptor (ED) has been hard to develop. It is currently anticipated that a number of important agricultural pesticide active substances could be defined as endocrine disruptors.

This report sets out the potential economic impacts of yield loss for the withdrawal of active substances on 51 horticultural, arable and forestry crops based on information available at September 2014. The impacts are calculated for 3 cumulative scenarios:

- Scenario 1: Active substances most likely to be lost- 10 fungicides, 3 herbicides and 4 insecticides
- Scenario 2: Scenario 1, plus active substances less likely to be lost unless a strict definition is taken – an additional 11 fungicides, 7 herbicides and 2 insecticides
- Scenario 3: Scenario 2, plus active substances for which there is insufficient information available to determine whether they will be classified as endocrine disruptors – an additional 10 fungicides, 11 herbicides (including one used as a sprout suppressant) and 8 insecticides.

The categorisation of actives substances was based on WRC (2013) and information provided by European Crop Protection Association.

The impact of the loss of active substances is calculated from the farmgate value of any yield loss. Yield impacts were provided by industry experts selected by AHDB and validated by ADAS. The yield impacts focused on the production year following the loss of active substances, and therefore do not account for longer term issues such as resistance, but these are highlighted where relevant. It was assumed that all active substances in a scenario were lost at the same time and that mitigating actions, such as alternative chemistry, would be used where available, although any change in cost was not included. Farmgate values were based on yield and market values from John Nix[1] 2010-2013 and/or industry experts based on 2013 data unless otherwise stated.

The results are presented at **industry** level, for 4 **sectors** (edible horticulture, ornamental horticulture, other edible crops – cereals, oilseeds, pulses, potatoes, sugar beet, hops and

[1] John Nix Farm Management pocket book – 2010-2013.

vines – and forestry), 14 **crop groups** (alliums, field vegetables, outdoor salads, protected edibles, soft fruit, tree fruit, ornamentals, cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines and forestry) and for 51 **individual crops**.

Summary of industry and sector level impacts (Table 1)

Note: The figures are presented as the loss in value in £M and the % of the total value of the relevant sector, crop group or crop.

Table 1 Industry and sector level impacts of the withdrawal of active substances in 3 different scenarios.

		Total industry		Sector							
				Edible horticulture		Ornamental horticulture		Other edible (cereals, oilseeds, pulses, potatoes, sugar beet)		Forestry	
		£M	%	£M	%	£M	%	£M	%	£M	%
Farm gate value	**(£M)**	**8,973**		**1,668**		**1,243**		**5,658**		**404**	
Scenario 1	Fungicides	413	5%	170	10%	164	13%	79	1%	0	0%
Scenario 1	Herbicides	123	1%	57	3%	1	0%	66	1%	0	0%
Scenario 1	Insecticides	369	4%	204	12%	152	12%	6	0%	6	1%
Scenario 1	All pesticides	905	10%	431	26%	317	26%	151	3%	6	1%
Scenario 2	Fungicides	587	7%	291	17%	199	16%	97	2%	0	0%
Scenario 2	Herbicides	513	6%	122	7%	2	0%	388	7%	1	0%
Scenario 2	Insecticides	465	5%	285	17%	162	13%	13	0%	6	1%
Scenario 2	All pesticides	1567	17%	697	42%	364	29%	498	9%	7	2%
Scenario 3	Fungicides	1149	13%	424	25%	257	21%	468	8%	0	0%
Scenario 3	Herbicides	851	9%	275	16%	94	8%	480	8%	1	0%
Scenario 3	Insecticides	926	10%	610	37%	211	17%	99	2%	6	1%
Scenario 3	PGR	226	3%	0	0%	0	0%	226	4%	0	0%
Scenario 3	All pesticides	3003	33%	1168	70%	566	46%	1262	22%	7	2%

Scenario 1

The reduction in industry farmgate value under scenario 1 across all 51 crops is estimated at £905M or 10% of farmgate value, with the largest impact in the horticulture sectors. Edible horticulture is expected to sustain the greatest impact accounting for £431M which is equivalent to 26% of the sector farmgate value while ornamental horticulture accounts for £317M in lost yield, equivalent to 26% of the sector farmgate value. Other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) account for £151M of

losses, equivalent to 3% of the sector farmgate value, while forestry has estimated losses of £6M or 1% of forestgate value.

To give an indication of the scale of the impacts crops with losses over 50% and 33% have been identified. These figures do not reflect whether or not the crop remains viable, as further gross margin information is needed to do that. There are some large losses in the edible horticulture crops, with yield losses of over 50% in ***protected salad leaves*** and ***rhubarb***. There are a number of crops with over 33% reductions in yields including ***leeks, salad onions, asparagus, carrot, blackberry, raspberry, strawberry,*** and ***hops***. Most other horticultural crops would suffer at least some reductions in yield that would make crops less profitable to produce.

The active substances lost in this scenario that are of greatest importance in terms of the value of crop impacts are **abamectin, thiacloprid, prochloraz, iprodione, linuron, mancozeb** and **tebuconazole**.

Scenario 2

This scenario includes all the losses from scenario 1 plus additional losses due to potential withdrawal of a further 20 active substances which may be classified as endocrine disruptors depending on the definition used.

The reduction in industry farmgate value under scenario 2 across all 51 crops is estimated at £1567M or 17% of farmgate value. Edible horticulture accounts for the largest proportion with losses estimated at £697M which is equivalent to 42% of the sector farmgate value, while ornamental horticulture losses are estimated at £364M which is equivalent to 29% of the sector farmgate value. Other edible crops (cereals, oilseed, pulses, potatoes, sugar beet, hops and vines) losses are estimated at £498M which is equivalent to 9% of the sector farmgate value, while forestry losses are estimated at £7M or 2% of forestgate value.

In scenario 2, a number of crops are expected to suffer yield losses of over 50%, including; ***leeks, asparagus, baby leaf brassicas, celery, protected salad leaves, rhubarb, strawberry,*** and ***hops***. There would also be an increasing number of crops with yield losses in excess of 33%, including; ***salad onions, beetroot, lettuce, blackberry, raspberry, pome fruit, Sweet Williams (cut flowers), sugar beet*** and ***vines***. Other crops will also become increasingly difficult to grow economically e.g. ***potatoes*** due to loss of **metribuzin** for weed control; **winter oilseed rape** and **field beans** where blackgrass is present due to the loss of **propyzamide** and **carbetamide**.

The key active substances affected in scenario 2 are **metribuzin** (especially in potatoes), **deltamethrin, propyzamide**, **carbetamide, bupirimate** and **difenoconazole**.

Scenario 3

This scenario includes all the losses of scenario 2 plus losses from the withdrawal of 29 active substances that have not yet been assessed, but may be classified as endocrine disruptors.

The total reduction in farmgate value under scenario 3 across all 51 crops is estimated at £3003M or 33% of the farmgate value. There are significant impacts in the 3 main cropping sectors. Edible horticulture accounts for £1168M of the losses which is equivalent to 69% of the sector farmgate value, while ornamental horticulture accounts for £566M of the losses, which is equivalent to 46% of the sector farmgate value. Other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) have losses of £1,262M which is equivalent to 22% of sector farmgate value, while forestry losses are £7M or 2% of forestgate value.

The combined loss of all the active substances in scenario 3 would result in the following crops suffering estimated yield losses in excess of 50%; ***bulb onions, leeks, salad onions, asparagus, beetroot, baby leaf brassicas, carrot, courgette and cucurbits, baby leaf brassicas, celery, outdoor lettuce, spinach, protected salad leaves, protected salads lettuce, blackberry, blackcurrant, raspberry, rhubarb, strawberry, pome fruit, , fresh beans, fresh peas, other pulses, sugar beet, hops*** and ***vines***. There would also be additional crops with yield losses in excess of 33% these crops include; ***protected peppers, cider fruit, stone fruit, bulbs and outdoor cut flowers, bedding and pot plants, hardy nursery stock, oilseed rape*** and ***potatoes***. All other crops are expected to suffer at least some impact with the exception of ***sunflowers*** which have very low pesticide usage and none of the approved actives are included in this assessment.

The five most important active substances, in terms of value of crop lost if withdrawn are; **chlorpropham** (£226M), **thiacloprid** (£187M), **metribuzin** (£167M), **abamectin** (£154M) and **prothioconazole** (£138M). The top five active substances in terms of the number of crops assessed impacted by their loss are **lambda cyhalothrin** (28 crops), **chlorpyrifos** (22 crops), **spinosad** (22 crops), **thiacloprid** (21 crops) and **deltamethrin** (18 crops).

Conclusions

Industry perspective

Impact on production: The farmgate value of lost production calculated in this report highlights the potential economic impact on farmers, and demonstrate the likely change in production levels. The yield losses in scenario 1 (most likely active substances to be lost) across the edible crops are equivalent to a 2.4M tonne reduction in food production, in scenario 2 this rises to 5.7M tonnes and in scenario 3 the losses could equate to 14.2M

tonnes. This compares to an estimated total UK production from these crops of 46.3M tonnes so represents a significant change in productive capacity.

Uncertainty: A key factor in the impact is the final definition of what an endocrine disruptor is, and whether further work will result in the inclusion of others that are currently uncertain due to lack of information. However, there is a degree of certainty over scenario 1, with impacts on the industry estimated to be £905M or 10% of the industry farmgate value. The uncertainty of inclusion of active substances in scenarios 2 and 3 mean that the worst case may not be realised, however the estimated losses of up to £3,003M is equivalent to 33% of the industry farmgate value and will be very serious for many sectors of the food production industry.

Timescales: There is an assumption in each of the scenarios that all the actives will be withdrawn at the same time in the near future, which will not allow any time for the development of alternative approaches, or for the market to adjust, however it is expected that in scenarios 2 and 3 the additional losses could be more staggered (see section below).

Additional farm impacts: This assessment looks at the impact of loss of active substances on yield and value of the crop and does not take into account the effect on crop viability, or costs of adaptation. There are a range of other potential impacts that are outside the scope of this study, but would benefit from further analysis, these include;

- *Crop viability*. Loss of marketable yield has an impact on the crop economics, and this is one aspect of decisions on crop viability. Decisions on which crop to grow will depend on a range of factors including market prices, costs of production and expected yields, as well as alternative options. The point at which a crop becomes unviable will vary for different crops and production systems.
- *Business viability*: For some, the loss of marketable yield could be a threat to business viability, particularly on smaller holdings with fewer alternative options. This is particularly the case where businesses have very specialised infrastructure, or capital investment, targeted at particular crops or groups of crops. They could be more vulnerable to the loss of active substances within their crop as their ability to switch to alternative crops will be compromised.
- *Adaptation.* Farmers and growers will take mitigating actions to minimise any potential yield loss, such as using alternative active substances where available, modifying their production systems or using new technology. Adoption of simple, currently available measures (such as alternative active substances) have been included in calculation of the yield impacts, however their costs have not been

included. There could also be potential to maintain yields through more complex changes to production systems, but these have not been assessed.

- *Resistance*. A range of active substances with different modes of actions are required to prevent resistance developing in target organisms. The loss of one or more active substances active against the target organism will impact on the ability of farmers and growers to achieve best practice resistance management strategies as set out by the Resistance Action Groups.

Sector variations

- The largest impacts are expected in the sectors where there are limited pesticide active substances available, and therefore fewer potential alternatives available in the event of losing and active substance.
    - The horticultural sectors (edible and ornamental) are severely affected, with the added challenge of high quality specifications for produce
    - Where profitability is sufficiently high the horticultural sector is highly innovative and has the potential to adapt, but it is likely to cost more. Those parts of the sector with lower profitability or highly specialised growing systems will find it more difficult to adapt. Further work would be required to identify which crop groups could and could not adapt and the timescale needed for change.
- The impacts in the other edible crops are mixed, with crops such as **potatoes**, **sugar beet** and **hops** more severely affected than the cereals.

Timescale of impacts

There are a number of options and categories that have been set out by the EU[2] in a roadmap for developing the definitions of endocrine disruptors. A public consultation was launched in 2014 and it is expected that a decision on the final definition of endocrine disruptors will be made following the conclusion of the consultation in 2015. Those active substances in our scenario 1 are most likely to be lost and the assumption is that if clearly defined as an endocrine disruptor they will be withdrawn fairly soon (1-2 years) after the decision is made. Those active substances in our scenarios 2 and 3 are likely to require more evidence to support their continued approval and this will take time to develop. Therefore the loss of these active substances, is expected to be more drawn out with staggered loss of active substances.

[2] http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2014_env_009_endocrine_disruptors_en.pdf

Wider industry implications

The loss of pesticide active substances is likely to have implications beyond the farmgate which have not been assessed in this report. The key impacts include;

- *Land use change.* Some crops, particularly horticulture crops, will become unviable under current production systems and market prices. This could lead to change in land use, which may have economic and environmental impacts either positive or negative.
- *Food, feed and fuel supply chains.* Changes in UK production could affect a wide range of supply chains including the limitations on quantity and quality of horticulture produce, supply of wheat for milling, storage of potatoes for crisping, and timing of supply, which may affect food prices and imports, investment and jobs.
- *Plant health implications.* Having a range of plant protection products enables the control of new plant health pest and disease threats

Interpretation of figures

The figures presented are necessarily estimates of the likely impacts occurring as a result of loss of actives. A key point to highlight is that losses will vary from year to year, region to region and farm to farm. A loss that may be bearable for one grower may be disastrous for another so social impacts may be variable also. As has been said it is assumed that all changes in active availability occur at a single point in time but industry has a history of being able to respond to challenges however, this will only occur over the long term.

Caveats

Data provided by experts appointed by AHDB. ADAS has made every effort to ensure that the data provided are as consistent and accurate as possible, but cannot be held responsible for the accuracy of data provided by external parties.

BACKGROUND

Under the revision of the pesticide approvals legislation and the implementation of European Union Plant Protection Products (PPP) Regulation (1107/2009) there has been a move from a risk to hazard based assessment criteria for the approvals of pesticide active substances. As part of this move it was identified that endocrine disrupting active substances should be classified as a hazard. However, the definition of endocrine disruptor (ED) has been hard to develop. It is currently anticipated that a number of important agricultural pesticide active substances could be defined as endocrine disruptors.

AHDB, plus other crop representatives such as PGRO (pulses) commissioned experts in crop production to conduct a series of studies on the impact of withdrawing endocrine disruption pesticides from the market. BBRO (sugar beet) provided information on the potential impacts using in house expertise.. These studies (referred to as expert returns) were based on the active substances identified in the WRC report (2013) which identifies the active substances that are more likely to be defined as endocrine disruptors, those that are less likely, those that need more information and those that are unlikely to be endocrine disruptors, providing three loss scenarios. The list of active substances identified by the WRC report was supplemented with information from reports produced by the European Crop Protection Association (ECPA). The expert returns are expert industry views of the cost implications due to reduction in yield from loss of each active identified as an ED in the respective crops.

This study collates the results of the various expert returns and distils the headline figures to give an overall picture of the potential impacts of withdrawal of endocrine disruptors on UK agriculture. The values presented focus on the impact on yields and do not take into account the increased cost of production associated with some of the alternative control options, although in many cases these additional costs have been highlighted in the text.

Scope

The following crops are covered in this assessment with the original authors identified;

Table 2 Crops assessed and original expert authors providing data

Crop	Expert Authors
Bulb onions	Allium and Brassica Centre
Leeks	Fresh Produce Consultancy
Salad onion	Allium and Brassica Centre
Asparagus	Claire Donkin
Beetroot	AH Agriculture & LJ Technical Consultancy
Brassicas	Allium and Brassica Centre
Carrot	Root Crop Consultancy

Crop	Expert Authors
Courgette and cucurbits	Grower and Member Cucurbit Growers Association
Sweetcorn	Sweetcorn Growers Association member
Baby Leaf brassica	Fresh Produce Consultancy
Celery	Fresh Produce Consultancy
Herbs	British Herb Trade Association
Lettuce	Fresh Produce Consultancy
Radish	Fresh Produce Consultancy
Spinach	Fresh Produce Consultancy
Cucumber	Cucumber Growers Association
Protected peppers	Member British Pepper Technology Group
Protected salads leaves	British Leafy Salads Association
Protected salads lettuce	British Leafy Salads Association
Tomato	Member British Tomato Growers Association
Blackberry	ADAS
Blackcurrant	Robert Saunders MSc, Blackcurrant Agronomy
Blueberries	Graham Moore
Raspberries - cane fruit	ADAS
Rhubarb	ADAS
Strawberry	ADAS
Cider fruit	Agrovista – worst case scenario
Pome fruit - call apples and pears	Agrovista – worst case scenario
Stone fruit	Agrovista – worst case scenario
Bedding and pot plants	ADAS
Bulbs and Outdoor Flowers (BOF),	Dick Evenden
BOF Aster	Dick Evenden
BOF Gladioli	Dick Evenden
BOF Narcissus	Dick Evenden
BOF Paeonia	Dick Evenden
BOF Sunflower	Dick Evenden
BOF Sweet Williams	Dick Evenden
Hardy nursery ornamental stock	Dove Associates
Oats	ADAS
Rye	ADAS
Spring barley	ADAS
Triticale	ADAS
Winter barley	ADAS
Winter wheat	ADAS
Maize	Maize Growers Association
Linseed	ADAS
Oilseed rape	ADAS
Soybean	ADAS (Soya UK)
Sunflower	ADAS
Fresh beans	PGRO
Fresh peas	PGRO
Pulse crops	PGRO
Potatoes	ADAS

Crop	Expert Authors
Sugar beet	BBRO
Hops	British Hops
Vines	United Kingdom Vineyards Association
Forestry	Crop Protection Advisor to Confor

Materials and methods

Expert returns were prepared by experts or stakeholders within each crop. These returns identified which pesticides would be affected by changes in pesticide availability due to the potential classification as endocrine disruptors and estimated the likely yield loss in a range of crops as a consequence, assuming no new chemistry.

The endocrine disruptor hazard criteria were divided into three groups, based on a paper produced by WRC (2013) and information provided by ECPA;

- Scenario 1 - Active substances more likely to pose a risk
- Scenario 2 - Active substances less likely to pose a risk
- Scenario 3 - Potential endocrine disruptors – further info needed

Each scenario is cumulative with the active substances in scenario 1 being lost in scenario 2 and the active substances from scenarios 1 and 2 also being lost in scenario 3. Details of the active substances included in each scenario are provided in Table 3.

The active substances in scenario 1 are those considered most likely to be defined as endocrine disruptors and are, therefore, the ones that are more likely to be withdrawn following the publication of the final definition. The active substances in scenario 2 are less likely to be defined as endocrine disruptors, unless the EU opt to take a stringent definition as the final definition. These active substances therefore have the potential to be lost, but the risk is less than for those in scenario 1. Those active substances in scenario 3 have a higher level of uncertainty around them as there is insufficient information available about their endocrine disruption properties to categorise them in either scenario 1 or 2. Nor can they be assumed to be completely safe from being defined as endocrine disruptors. Therefore the fate of these active substances is less certain, with the expectation that not all of these active substances would end up defined as endocrine disruptors, but some will. For the purposes of this assessment it is assumed that all active substances in scenario 3 will be lost.

Table 3 Active substances included in each scenario, based on WRC and ECPA data

ED more likely to pose a risk Human and Ecotox Approvals likely to be lost ***SCENARIO 1***	*ED less likely to pose a risk Approvals at risk* ***SCENARIO 2***	*Potential ED – further info. Required Approvals at risk* ***SCENARIO 3***
Fungicides		
WRC report Mancozeb Iprodione Myclobutanil Prochloraz Tebuconazole Additional active substances in ECPA report AND currently approved in UK Cyproconazole Epoxiconazole Fenbuconazole Maneb Metconazole	WRC report Bupirimate Thiophanate-methyl Additional active substances in ECPA report AND currently approved in UK Difenoconazole Folpet Fluquinconazole Fuberidazole Penconazole Propiconazole Tetraconazole Triademenol Triticonazole	WRC report Carbendazim Cymoxanil Fluazinam Fosetyl aluminium Hymexazol Mandipropamid Prothioconazole Silthiofam Thiram Chlorothalonil
Herbicides		
WRC report Ioxynil Linuron Additional active substances in ECPA report AND currently approved in UK Amitrole	WRC report Metribuzin Propyzamide Additional active substances in ECPA report AND currently approved in UK Carbetamide Chlorotoluron Fluometuron Picloram Triflusulfuron	WRC report 2,4-D Chlorpropham Dimethenamid-P Ethofumesate Fluazifop-p-butyl Glufosinate-ammonium Lenacil S-metolachlor Pinoxaden Tepraloxydim Terbuthylazine
Insecticides		
Abamectin Thiacloprid Cypermethrin Fenoxycarb	Spiromesifen Additional active substances in ECPA report AND currently approved in UK Deltamethrin	Chlorpyrifos Clothianidin Beta-cyfluthrin Lambda-cyhalothrin Spinosad Spirotetramat Dimethoate Malathion
Plant growth regulators		
		Chlorpropham (sprout suppressant – also included as herbicide)
TOTAL ACTIVE SUBSTANCES AFFECTED		
17	**20**	**29**

For each scenario the experts in the 51 crops assessed, calculated the yield loss due to withdrawal of each active substance, in the year that the active substances were lost (assuming that the active substances were all lost in the same year). In situations where a mixture containing the active is used in the crop it was assumed that that partner product would also be lost, unless available in mixture with another active ingredient that remains, or as a straight (unless otherwise stated).

The expert returns were checked by ADAS to make sure that the methodology applied was consistent and that the figures appeared to be justified. ADAS have tried to ensure that all numbers presented are purely based on yield loss, as per the original brief, i.e. do not include the changes in production costs from alternative control measures. All yield impacts and resultant reductions in industry value are annual, based on the year of loss and therefore do not take into account development of resistance (although where relevant this is commented on in the text). Yield losses and reduction in farmgate value of the industry are calculated to the farmgate and will therefore be considerably greater for some crops if processing/packing value were included.

Where possible yield losses have taken account of the proportion of the crop area treated with an active substance (using pesticide usage survey statistics, or industry statistics) and the resultant loss of yield on that area (i.e. a weighted yield loss), therefore organic crops should not be included in the impacts as these crops are not treated. This yield loss should be the typical yield loss in a 'normal' year. However, there are a number of the expert returns that do not appear to have been calculated in this way, with either no mention of the proportion of the crop area treated, or worst case scenario yield losses used, and these have been highlighted.

All figures presented are UK figures, based on UK crop areas and yields from Defra Agricultural Statistics[3] , for the main cereal, oilseed and pulse crops, Defra Horticultural statistics[4] for the main horticultural crops and levy body or grower group data for the minor crops. Some of the smaller horticultural crops provided GB figures, but given the small area of horticulture in Northern Ireland these have not been adjusted.

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[3] Defra Statistics (2013) Structure of the agricultural industry in England and the UK at June (UK annual time series) https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june

[4] Defra Statistics (2013) Basic horticultural statistics https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/141608/hort-report-31jul13.pdf

Once checked the returns were collated into a single matrix and key messages for each crop were identified.

Based on these individual crop vs active combinations and the associated yield loss, the farmgate value of the impacts were calculated for each crop, crop group, sector and the industry based on national area and current prices of marketable crop (2013 for horticulture unless otherwise stated, five year average cereals, oilseeds and potatoes 2010-2013). Prices were provided by the crop experts / levy bodies market information, with supporting information from John Nix farm management pocket book[5]. Where mitigation was possible, i.e. using a different active substance, this was taken in to account in the level of yield loss, but the cost of this change was not included, as per the methodology set out by HDC. In addition the experts provided some commentary on each crop to explain the impacts, and if there are further impacts expected, e.g. through the build-up of resistance. Any active substances that had significant yield impacts associated with its loss was highlighted.

For field grown crops calculations were based on the yield loss per hectare and the area treated and then scaled up to the national area. For the ornamental crops that tend to be container grown calculations were made based on the proportion of the marketed crop that is treated and the proportion that would be lost in the absence of an active substance. Both methods produce a lost value to the industry and percentage reduction in value that can be looked at as consistent figures.

Caveats

ADAS has made every effort to ensure that the data provided are as consistent and accurate as possible, but cannot be held responsible for the accuracy of data provided by external parties.

Report structure

The information is presented in the results section with an industry and sector summary followed by results by crop group and crop (in alphabetical order as per Figure 1). **Active substances** are highlighted in bold whilst ***crop groups*** and ***crops*** are highlighted in bold and italics.

[5] John Nix Farm Management pocket book – 2010-2013

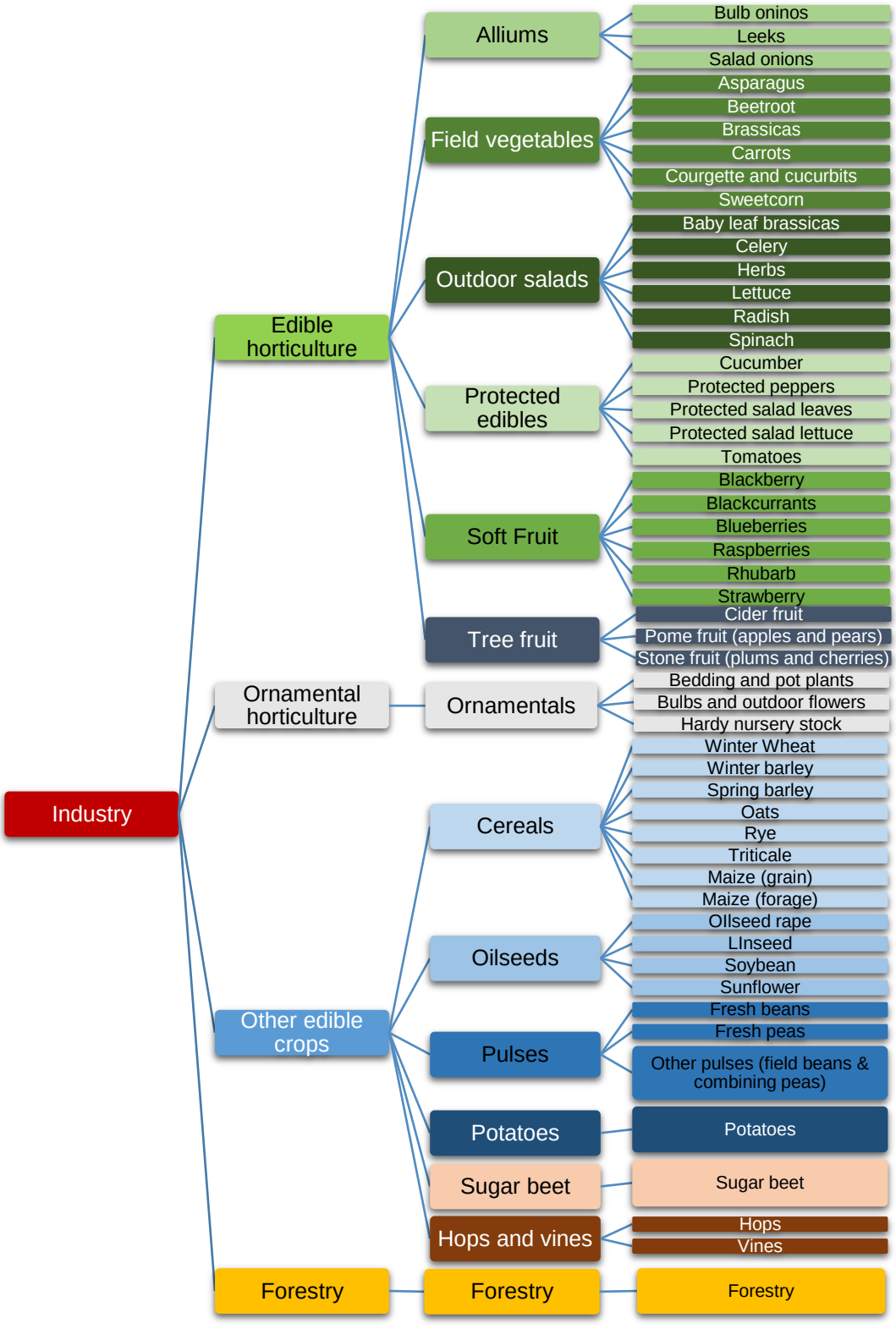

Figure 1 Structure of report - industry, sector, crop groups and crops as used in this report

Results

All results are presented as change in farmgate value due to yield loss in £M, and % reduction in farmgate value (e.g. £120M – 6%) to enable the analysis of impacts between sectors and crop groups of different sizes. The % figure presented may be the loss relative to the farmgate value of the sector, crop group or individual crop farmgate value and will be clearly stated. Note that all values are rounded for clarity of presentation and therefore the lost value figure and percentage may not exactly equal the same proportion of the total value.

The results are presented in the following sections

- An industry overview for each scenario
- Sector and crop group impacts for each scenario
- An analysis of the key active substances that cause the largest impacts
- Supporting crop level information

Industry and sector impacts

The total farmgate value of all of the sectors is calculated at £8973M. This is made up of the edible horticulture sector £1668M, the ornamental horticulture sector £1243M per year and other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) £5658M per year and forestry £404M.

Scenario 1 contains the smallest number of active substances (17), but these are considered to be the active substances that are most likely to be lost. The value of estimated yield losses at the industry level in this scenario is £905M or 10% of the total farmgate value. The individual sectors are affected differently with major losses in ***edible horticulture*** of £431M or 26% of sector farmgate value and ***ornamental horticulture*** £317M - 26% of sector farmgate value and ***other edible crops*** including ***cereals, oilseeds, pulses, potatoes, sugar beet, hops*** and ***vines*** totalling losses of £151M or 3% of the sector farmgate value, while ***forestry*** losses are lower at £6M or 1% of forestgate value.

The additional loss of active substances that are less at risk in **scenario 2** increases these losses to £1567M or 17% of farmgate value at the industry level, with increases across all sectors. Edible horticulture losses are estimated to be £697M or 42% of sector farmgate value, ornamental horticulture £364M - 29% of sector farmgate value and other crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) £498M or 9% of sector farmgate value, while forestry losses total £7M. In this scenario the increased yield losses across the edible horticulture and ornamental horticulture sectors will mean that production of certain crops will no longer be viable in the UK.

The extent of the losses in **scenario 3** would make most horticultural and certain arable crop groups economically unviable. The value of yield losses would rise to £3,003M or 33% of farmgate value across all sectors. Edible horticulture would lose £1168M or 70% of sector farmgate value, ornamental horticulture £566M - 46% of sector farmgate value, other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) £1262M or 22% of sector farmgate value and forestry £7M – 2% of forestgate value.

Table 4 Industry and sector level impacts of each of the scenarios.

		Total industry		Edible horticulture		Ornamental horticulture		Other edible (cereals, oilseeds, pulses, potatoes, sugar beet)		Forestry	
		£M	%	£M	%	£M	%	£M	%	£M	%
Farm gate value	**(£M)**	**8,973**		**1,668**		**1,243**		**5,658**		**404**	
Scenario 1	Fungicides	413	5%	170	10%	164	13%	79	1%	0	0%
Scenario 1	Herbicides	123	1%	57	3%	1	0%	66	1%	0	0%
Scenario 1	Insecticides	369	4%	204	12%	152	12%	6	0%	6	1%
Scenario 1	All pesticides	905	10%	431	26%	317	26%	151	3%	6	1%
Scenario 2	Fungicides	587	7%	291	17%	199	16%	97	2%	0	0%
Scenario 2	Herbicides	513	6%	122	7%	2	0%	388	7%	1	0%
Scenario 2	Insecticides	465	5%	285	17%	162	13%	13	0%	6	1%
Scenario 2	All pesticides	1567	17%	697	42%	364	29%	498	9%	7	2%
Scenario 3	Fungicides	1149	13%	424	25%	257	21%	468	8%	0	0%
Scenario 3	Herbicides	851	9%	275	16%	94	8%	480	8%	1	0%
Scenario 3	Insecticides	926	10%	610	37%	211	17%	99	2%	6	1%
Scenario 3	PGR	226	3%	0	0%	0	0%	226	4%	0	0%
Scenario 3	All pesticides	3003	33%	1168	70%	566	46%	1262	22%	7	2%

CROP GROUPS AND CROP IMPACTS

The individual **crop group impacts** for each of the scenarios are summarised in Table 5 and Table 6. These tables also include an analysis of the active substances (by fungicide, herbicide or insecticide). These are discussed in the following sections by scenario, crop group and individual crops.

Key points

Scenario 1

- ***Edible horticulture*** accounts for 48% of the lost industry value, £431M or 26% of the total value of edible horticulture.

    - The largest losses in this sector are in ***alliums*** (£38M – 32%), ***field vegetables*** (£137M – 27%), ***soft fruit*** (£148M – 40%) and ***tree fruit*** (£53M - 27%)
- ***Ornamental horticulture*** accounts for 35% of the lost industry value, £317M or 26% of the sector value
- The ***other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet***, ***hops*** and **vines**) sector accounts for 17% of the loss in industry value (£151M) but this is only 3% of the sector value
- The following crops would suffer more than 50% reduction in yield ***protected salad leaves*** and ***rhubarb***.

Scenario 2

- ***Edible horticulture*** accounts for 45% of the lost industry value at £697M - which is 42% of the sector value.
    - The worst affected crop groups (lost value - % reduction in crop group value) are ***alliums*** (£40M – 34%), ***field vegetables*** (£213M – 42%), ***outdoor salads*** (£101M – 35%), ***soft fruit*** (£250M – 67%) and ***tree fruit*** (£71M – 36%)
- ***Ornamental horticulture*** accounts for 23% of the industry level losses at £364M - which is 29% of the sector level value.
- The ***other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet***, ***hops*** and **vines**) sector accounts for 32% of the loss in industry value (£498M) which is 9% of the sector value
    - The largest impacts in this sector are seen in the ***oilseeds*** (£150M – 22%), ***pulses*** (£47M – 20%), ***potatoes*** (£193M – 21%), ***sugar beet*** (£74M – 33%) and ***hops and vines*** (£14M – 65%)
- The following crops would suffer yield losses of over 50%; ***leeks, asparagus, baby leaf brassicas, celery, protected salad leaves, rhubarb, strawberry*** and ***hops***

Scenario 3

- ***Edible horticulture*** accounts for 39% of the lost industry value at £1168M - which is 70% of the sector value.
    - The worst affected crop groups (lost value - % reduction in crop group value) are ***alliums*** (£90M - 77%), ***field vegetables*** (£386M – 76%), ***outdoor salads*** (£218M – 70%), ***soft fruit*** (£334M – 89%) and ***tree fruit*** (£109M – 55%)

- ***Ornamental horticulture*** accounts for 19% of the industry level losses at £566M - which is 46% of the sector level value.
- The ***other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet***, ***hops*** and **vines**) sector accounts for 42% of the loss in industry value (£1262M) which is 22% of the sector value
    - The largest impacts in this sector are seen in the ***oilseeds*** (£246M – 36%), ***pulses*** (£153M – 65%), ***potatoes*** (£422M – 47%), ***sugar beet*** (£184M – 82%) and ***hops and vines*** (£21M – 100%)
- The following crops would suffer yield losses of over 50%; ***bulb onions***; ***leeks, salad onions, asparagus, beetroot, brassicas, carrot, courgette and cucurbits, baby leaf brassicas, celery, lettuce, spinach, protected salad leaves, protected lettuce, blackberry, blackcurrant, raspberry, rhubarb, strawberry, pome fruit (apples and pears), fresh beans, fresh peas, other pulses, sugar beet*** and ***hops***

Table 5. Value of yield impacts due to loss of pesticides – edible horticulture and ornamental horticulture sectors – by crop group

		All alliums	Field Vegetables	Outdoor salads	Protected edibles	Soft fruit	Tree fruit	Ornamentals
Crop area	**(ha)**	**12,290**	**49,147**	**14,295**	**830**	**9,723**	**19,147**	**5,000**
Production	**(t)**	**425,100**	**1,306,650**	**226,770**	**174,860**	**146,691**	**547,292**	**0**
Farm gate value	**(£M)**	**£116**	**£511**	**£289**	**£181**	**£374**	**£197**	**£1,243**
Scenario 1	Fungicides	£29	£37	£36	£3	£54	£11	£164
Scenario 1	Herbicides	£5	£35	£14	£0	£2	£0	£1
Scenario 1	Insecticides	£3	£65	£4	£5	£92	£35	£152
Scenario 1	All pesticides	£38	£137	£54	£7	£148	£46	£317
Scenario 2	Fungicides	£31	£63	£41	£11	£111	£34	£199
Scenario 2	Herbicides	£5	£69	£30	£1	£17	£0	£2
Scenario 2	Insecticides	£3	£81	£31	£10	£122	£37	£162
Scenario 2	All pesticides	£40	£213	£101	£22	£250	£71	£364
Scenario 3	Fungicides	£45	£136	£55	£23	£132	£34	£257
Scenario 3	Herbicides	£31	£97	£67	£1	£69	£11	£94
Scenario 3	Insecticides	£18	£167	£95	£25	£240	£64	£211
Scenario 3	PGR	£0	£0	£0	£0	£0	£0	£0
Scenario 3	All pesticides	£90	£386	£218	£47	£334	£109	£566

CL – complete loss of production

Table 6 Value of yield impacts due to loss of pesticides – other edible crops and forestry sectors by crop group

		Cereals	Oilseeds	Pulses	Potatoes	Sugar beet	Hops and vines	Forestry
Crop area (Kha)		3,129	726	191	122	120	3	3,127
Production (Kt)		26,682	2,461	779	5,500	8,000	1	10,616
Farm gate value (£M)		3,582	693	237	900	224	21	404
Scenario 1	Fungicides	£13	£6	£22	£3	£30	£5	£0
Scenario 1	Herbicides	£0	£0	£14	£52	£0	£0	£0
Scenario 1	Insecticides	£0	£0	£4	£0	£0	£2	£6
Scenario 1	All pesticides	£13	£6	£40	£56	£30	£7	£6
Scenario 2	Fungicides	£20	£6	£22	£3	£38	£7	£0
Scenario 2	Herbicides	£0	£144	£16	£189	£35	£3	£1
Scenario 2	Insecticides	£0	£0	£9	£0	£0	£4	£6
Scenario 2	All pesticides	£20	£150	£47	£193	£74	£14	£7
Scenario 3	Fungicides	£194	£102	£91	£5	£61	£15	£0
Scenario 3	Herbicides	£21	£144	£22	£189	£98	£6	£1
Scenario 3	Insecticides	£22	£0	£40	£1	£25	£12	£6
Scenario 3	PGR	£0	£0	£0	£226	£0	£0	£0
Scenario 3	All pesticides	£237	£246	£153	£421	£184	£21	£7

Scenario 1

In scenario 1, there are 17 active substances that are assumed to have a high risk of approvals being removed as a result of them being defined as endocrine disruptors. The total cost of the scenario across all 51 crops assessed is estimated at £905M or 10% of farmgate value across all sectors. Edible horticulture accounts for £431M or 26% of sector farmgate value, ornamental horticulture £317M or 26% of sector farmgate value, other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) £151M or 3% of sector farmgate value and forestry £6M or 1% of forestgate value.

There are differences in impacts between crop groups within each key sector discussed below, and shown in Table 7 and Table 8. In addition to the value of yield losses, there are expected to be increases in the cost of production as farmers and growers have to switch to more expensive or more frequent applications of alternative active substances or have to increase labour requirements to maintain quality, but these costs are not included in this analysis.

Table 7 Value of yield losses in main crop groups under scenario 1, showing reduction in farmgate value of the crop group (£M) and the percentage reduction in crop group farmgate value (%) – edible horticulture and ornamental horticulture

Scenario 1	All alliums	Field Vegetables	Outdoor salads	Protected edibles	Soft fruit	Tree fruit	Ornamentals
(ha)	12,290	49,147	14,295	830	9,723	19,147	
(t)	425,100	1,306,650	226,770	174,860	146,691	547,292	
(£M)	£116	£511	£289	£181	£374	£197	£1,243
Fungicides	£29	£37	£36	£3	£54	£11	£164
Herbicides	£5	£35	£14	£0	£2	£0	£1
Insecticides	£3	£65	£4	£5	£92	£35	£152
All pesticides	£38	£137	£54	£7	£148	£46	£317
Fungicides	25%	7%	12%	1%	14%	6%	13%
Herbicides	5%	7%	5%	0%	0%	0%	0%
Insecticides	3%	13%	1%	3%	25%	18%	12%
All pesticides	32%	27%	19%	4%	40%	23%	26%

Table 8 Value of yield losses in main crop groups under scenario 1, showing reduction in farmgate value of the crop group (£M) and the percentage reduction in crop group farmgate value (%) – other edible crops and forestry, and total for all crops

Scenario 1	Cereals	Oilseeds	Pulses	Potatoes	Sugar beet	Hops and vines	Forestry	Industry level
(Kha)	3,129	726	191	122	120	3	3,127	753
(Mt)	26,682	2,461	779	5,500	8,000	1	10,616	56,869
(£M)	£3,582	£693	£237	£900	£224	£21	£404	£8,973
Fungicides	£13	£6	£22	£3	£30	£5	£0	£413
Herbicides	£0	£0	£14	£52	£0	£0	£0	£123
Insecticides	£0	£0	£4	£0	£0	£2	£6	£369
All pesticides	£13	£6	£40	£56	£30	£7	£6	£905
Fungicides	0%	1%	9%	0%	13%	23%	0%	5%
Herbicides	0%	0%	6%	6%	0%	0%	0%	1%
Insecticides	0%	0%	2%	0%	0%	10%	1%	4%
All pesticides	0%	1%	17%	6%	13%	32%	1%	10%

The largest cause of yield losses in scenario 1 across all sectors is a reduced ability to control disease and pests with losses due to fungicide withdrawal estimated to reduce the farm gate value by £413M or 5%, in reduced yields, and losses due to insecticide withdrawal estimated to reduce the value of the industry by £369M or 4% of farmgate value,

in reduced yields, mostly in the edible and ornamental horticulture sectors. A reduction in weed control is expected to reduce the farm gate value by £123M or 1% of farmgate value, in reduced yields across all sectors.

The edible horticulture sector is severely affected by the losses in scenario 1 with, ***alliums*** £38M - 32%, ***field vegetables*** £137M - 27%, ***soft fruit*** £148M - 40%, and ***hops and vines*** £7M – 32% and suffering the greatest reductions in value in relation to the size of the industry. A number of crops would no longer be economically viable to grow in the UK, at current prices, including ***leeks, salad onions, rhubarb, strawberries*** and ***hops***.

The ***soft fruit*** crop group is estimated to reduce in value by £148M – 40% in the event of the losses in scenario 1. The main source of losses is expected to come as a result of reduced pest control £92M – 25%, with the consumer having zero tolerance for damage or contamination in their fruit. The loss of **thiacloprid** is the greatest concern accounting for £58M – 16%, although loss of **abamectin** would also lead to challenges in two spotted spider mite control with associated losses of £34M – 9%. Loss of fungicides and resultant reductions in disease control would also be significant accounting for £53M – 13%.

- ***Rhubarb*** (£13M - 50%) would be the worst affected crop, all as a result of lost disease control following the withdrawal of **mancozeb** – £8.0M - 31% (black top) and **iprodione** £5.0M - 19% (downy mildew). There is a high concentration of rhubarb grown in the 'rhubarb triangle' in Yorkshire. It is expected that in this scenario a high proportion of these growers, especially those producing forced rhubarb would go out of production.
- ***Strawberries*** (£98M - 44%) would also be badly affected, but this time as a result of reduced pest control (thrips, mites, capsids and weevils). At this level of loss it is expected that a number of strawberry growers would cease production due to poor returns and the increased risk of production.
- ***Raspberry*** and ***blackberry*** industries are expected to reduce by 35%, £32M and £2.9M respectively predominantly as a result of reduced pest control.

Allium crops are estimated to reduce in value by £38M – 32%, predominantly as a result of the loss of disease control (£29M – 25%). The loss of **mancozeb** alone, predominantly for downy mildew control accounts for the largest impact on yield (£22M – 19%). The ***leek*** and ***salad onion*** industries are expected to be worst hit losing £12.7M – 42% and £10.4M – 40% of their value respectively, making conventional production of these crops unviable in the absence of these active substances.

- ***Leeks*** are expected to suffer from reduced disease control especially rusts as a result of the loss of **tebuconazole** (£4.5M – 15%), weed control following the loss of

linuron (£3M – 10%) and pest control, all of which contribute to the high losses in this scenario, whilst ***salad onions*** are expected to suffer very high losses to disease following the loss of **mancozeb** (£9M – 35%) in particular, with spring and autumn production becoming uneconomic. Loss of **tebuconazole** would result in field affected by white rot being complete taken out of production (£1.3M – 5%).

- ***Bulb onions*** are less affected than the other alliums, with losses of £14.4M - £24%. Loss of **mancozeb** (£11M – 18%), would result in reduced ability to control downy mildew, with increasing resistance a concern. Production off bulb onions would be challenging, especially in areas affected by white rot, which would become completely unviable in the absence of **tebuconazole** (£1.2M – 2%). In consistency of supply would lead to price volatility.

The ***field vegetable*** crop group is estimated to lose £137M – 27% of its crop group farmgate value and yield as a result of the losses in scenario 1. The loss of insecticides is the main threat accounting for £65M – 13% of the losses. The loss of **thiacloprid** is of the greatest concern accounting for £57M – 11% of the losses. The loss of fungicides is expected to reduce the value of the crop group by a further £37M – 7%, predominantly as a result of the loss of **tebuconazole** £20M – 4%. The loss of herbicides, specifically **linuron** is expected to reduce the value of the crop group by £35M - 7%.

- ***Carrots (***£45M – 36%) are the worst affected crop, predominantly as a result of the loss of **linuron** (£33M – 26%) and subsequent reductions in weed control.
- ***Asparagus, beetroot*** and ***courgette and cucurbits*** are all estimated to reduce in value by 30-33% (£9.5M - £9.0M and £12M) respectively, mostly as a result of reduced pest control following the loss of **thiacloprid** and to a lesser extent **cypermethrin.** In Asparagus there would be just one active (spinosad) left for asparagus beetle control, whilst in the other crops there would be reduced aphid and caterpillar control.
- ***Brassicas***, are expected to reduce in value by 22% suffering the greatest reduction in farmgate value at £65M. The largest loss would be as a result of reduced aphid control following the loss of **thiacloprid** (£41.8M – 15%).
- ***Sweetcorn*** is not expected to be affected by this scenario.

Ornamental horticulture is estimated to suffer losses of up to £317M – 26% as a result of the loss of disease control (£164M – 13%) and pest control (£152M – 13%).

- The largest losses would be in ***hardy nursery stock*** (£484M - 28%) followed by ***bedding and pot plants*** (£63M - 15%).

Outside of the horticultural crops the largest loss of value are from;

- ***Potatoes*** are estimated to reduce in value by £56M – 6%, almost entirely as a result of the reduction in weed control following the loss of **linuron** (£52M – 6%) and increased costs associated with loss of **mancozeb**[6] (£3M). The loss of mancozeb leads to serious concerns over resistance management of blight as increased numbers of applications of single mode of action active substances would be required in its absence. Future yield losses could therefore increase as resistance develops to remaining active substances.
- ***Pulse crops*** are estimated to reduce in value by £40M – 17%, due to reduced disease control following the loss of **cyproconazole** (£9.4M – 4%) and **tebuconazole** (£11M – 5%) and the loss of weed control following the loss of **linuron** (£14M – 6%).
- ***Sugar beet*** is expected to suffer losses of £30M – 13%, due to reduced disease control, mostly as a result of the loss of **cyproconazole** (£28M – 12%) for foliar disease control.
- ***Hops*** (£4M – 44%) and ***vines*** (£3M – 23%). It would become highly risky to grow hops in the UK without sufficient disease control options as there is very low tolerance for damage on this crop, with complete crop rejection a real risk. Loss of **myclobutanil** in hops would leave them at risk of powdery mildew damage reducing value and yields by (£2M – 22%). The loss of **abamectin** (£2M – 22%) would prevent hops growers from maintaining control of two spotted spider mite and as a result there is the risk of complete crop failure 1 year in 4. The increased riskiness of production of hops in scenario 1 is expected to drive a number of producers out of business. Vines would suffer reduced disease control as a result of the combined losses of **fenbuconazole, iprodione, mancozeb, myclobutanil** and **tebuconazole** (3M – 23%).

Scenario 2

In scenario 2 there are 20 *additional* active substances that are assumed to have a lower risk of approvals being removed as a result of them being defined as endocrine disrupting substances. The total value of yield losses in scenario 2 across all 51 crops assessed is

[6] Calculations for potatoes included some costs of mitigation, at the request of the Potato Council, as the replacement of mancozeb with more costly alternatives was considered to be an important impact, given that the loss of mancozeb would not actually result in significant yield losses.

£1567M or 17% of industry farmgate value. Edible horticulture is seriously affected with loss in value of £697M or 42% of the sector farmgate value, with ornamental horticulture accounting for a further £364M or 29% of sector farmgate value, other edible crops (cereals, oilseed, pulses, potatoes, sugar beet, hops and vines) a further £498M or 9% of sector farmgate value, and forestry £7M or 2% of forestgate value (Table 4). Details of the crop group estimates are shown in Table 9 and Table 10. There are also expected to be increases in the cost of production as farmers and growers have to switch to more expensive or more frequent applications of alternatives or have to increase labour requirements to maintain quality, however these additional costs are not captured in this analysis.

Table 9 Value of yield losses by crop groups for scenario 2, showing reduction in farmgate value of the crop group (£M) and the percentage reduction in crop group farmgate value (%) – edible horticulture and ornamental horticulture

Scenario 2	All alliums	Field Vegetables	Outdoor salads	Protected edibles	Soft fruit	Tree fruit	Ornamentals
(ha)	12,290	49,147	14,295	830	9,723	19,147	5,000
(t)	425,100	1,306,650	226,770	174,860	146,691	547,292	0
(£M)	£116	£511	£289	£181	£374	£197	£1,243
Fungicides	£31	£63	£41	£11	£111	£34	£199
Herbicides	£5	£69	£30	£1	£17	£0	£2
Insecticides	£3	£81	£31	£10	£122	£37	£162
All pesticides	£40	£213	£101	£22	£250	£71	£364
Fungicides	27%	12%	14%	6%	30%	17%	16%
Herbicides	5%	13%	10%	0%	5%	0%	0%
Insecticides	3%	16%	11%	6%	33%	19%	13%
All pesticides	34%	42%	35%	12%	67%	36%	29%

Table 10 Value of yield losses by crop group for scenario 2, showing reduction in farmgate value of the crop group (£M) and the percentage reduction in crop group farmgate value (%) - other edible crops and forestry, and all crops

Scenario 2	Cereals	Oilseeds	Pulses	Potatoes	Sugar beet	Hops and vines	Forestry	Industry Level
(Kha)	3,129	726	191	122	120	3	3,127	753
(t)	26,682	2,461	779	5,500	8,000	1	10,616	56,869
(£M)	£3,582	£693	£237	£900	£224	£21	£404	£8,973
Fungicides	£20	£6	£22	£3	£38	£7	£0	£587
Herbicides	£0	£144	£16	£189	£35	£3	£1	£513
Insecticides	£0	£0	£9	£0	£0	£4	£6	£465
All pesticides	£20	£150	£47	£193	£74	£14	£7	£1,567
Fungicides	1%	1%	9%	0%	17%	32%	0%	7%
Herbicides	0%	21%	7%	21%	16%	13%	0%	6%
Insecticides	0%	0%	4%	0%	0%	19%	1%	5%
All pesticides	1%	22%	20%	21%	33%	65%	2%	17%

The largest cause of yield losses in scenario 2 across all sectors is a reduced ability to control disease, which is expected to reduce value the value of the industry by £587M – 7% in reduced yields, mostly in the edible and ornamental horticulture sectors. Reduce control of weeds following the loss of herbicides is estimated to reduce the farm gate value by £513M – 6% in reduced yields. A reduction in pest control is expected to reduce the value of the industry by £513M – 6% through reduced yields across all sectors.

The loss of active substances in scenario 2 is expected to have a significant impact on the ability of growers to continue to produce a wide range of horticultural crops in particular, but also some arable crops. The worst affected crop groups in this scenario are; ***alliums*** (£40M – 34%), ***field vegetables*** (£213M – 42%), ***outdoor salads*** (£101M - 35%), ***soft fruit*** (£250M – 67%), ***tree fruit*** (£71M – 36%), ***ornamentals*** (£874M – 70%), ***oilseeds*** (£150M – 22%), ***pulses*** (£47M - 20%), ***potatoes*** (£193M – 20%) and ***sugar beet*** (£74M – 33%).

The ***soft fruit*** crop group is estimated to reduce in value by £250M – 67% in the event of the losses in scenario 2. The main source of losses is expected to come as a result of reductions in pest control £122M – 33%, with the consumer having zero tolerance for damage or contamination in their fruit. The additional loss of **deltamethrin** (£29M – 8%), as well as **thiacloprid** and **abamectin** from scenario 1, further reduces the ability of growers to economically control pests in the crop, increasing the risk of whole crop rejections. Spotted winged drosophila (SWD) have been reported in increasing numbers within the UK soft fruit

crop. This pest has the potential to devastate soft fruit crops. The loss of active substances such as deltamethrin that have activity against this pest could allow it to become more widespread within the UK crop, resulting in higher losses in the future. Loss of fungicides and resultant reductions in disease control would also be significant accounting for £111M – 30%. The worst affected crop would be ***strawberries*** £83M – 38%. There would be some modest reductions in yield following the withdrawal of the herbicides in scenario 2 (£17M – 5%).

- ***Strawberries*** (£184M - 83%) **-** The loss of active substances in scenario 2 is likely to result in conventional British strawberry production becoming unviable, due to combined yield losses of up to 83%. The loss of **bupirimate** (£28M – 13%) and **penconazole** (£28M – 13%) in addition to the loss of **myclobutanil** in scenario 1 would result in very limited options for powdery mildew control. This disease can be devastating especially on 60 day crops and ever bearers. The loss of **deltamethrin** (£23M – 11%) – could have serious implications in years where spotted winged drosophila is present. Strawberry production in England is focused predominantly in the West Midlands and South East (60%), with more modest areas in the Eastern region 13% and East Midlands (10%).
- ***Rhubarb*** (£17M – 66%) – The main impacts in terms of reduced yield in rhubarb came in scenario 1, with just small additional losses occurring in this scenario, due to reduced weed control following the loss of **propyzamide** (£2.6M - 10%) and reduced pest control following the loss of **deltamethrin** (£1.2M - 5%).
- ***Raspberries*** (£41M – 46%) and ***blackberries*** (£3.7M – 45%) are expected to suffer additional losses in pest control due to loss of **deltamethrin** (£4.5M and £0.4M respectively – 5%, losses could be greater if SWD becomes further established) and reduced weed control following the withdrawal of **propyzamide** (£3.5M and £0.4M respectively – 4-5%). Raspberry production tends to be focused in the South East of England with 42% of total English area here, a further 21% of the area is in the Eastern region, 18% is in the West Midlands and 15% is in the South West. There are also raspberry growers in eastern Scotland.

The ***field vegetable*** crop group is estimated to lose £213M – 42% of the farmgate value due to yield impacts as a result of the losses in scenario 2. The loss of insecticides remains the main threat accounting for £81M – 16% of the losses. The additional loss of **deltamethrin** increases losses by a further £16M – 3% over the loss of **thiacloprid** and **cypermethrin** in scenario 1. The loss of herbicides is expected to reduce the value of the sector by £69M - 13% mostly as a result of a loss of **metribuzin** in carrots (£25M – 20%).

The loss of fungicides is expected to reduce the value of the crop group by £63M – 12%, predominantly as a result of the loss of **difenoconazole** (£20M – 4%).

- ***Carrots*** (£83M – 66%) are the worst affected crop with a combined loss of **linuron** and **metribuzin** expected to reduce weed control, to levels similar to those experienced in organic systems, resulting in losses of £58M – 46%. In the absence of organic premiums the crop will become unviable without major changes in production methods.
- ***Courgettes and cucurbits*** (£20M – 50%) are also severely affected as a result of the combined loss of **myclobutanil** (£6.0M – 15%) and **bupirimate** (£6.0M – 15%) for powdery mildew control and **thiacloprid** (£6.0M – 15%) for aphid vector control in scenario 1.
- ***Asparagus*** (£14M – 50%) it will become increasingly difficult to control weeds in these perennial crops as a result of the loss of **linuron** (£2.3M – 8%) and **metribuzin** – (£3.5M – 12%). When combined with the loss of the insecticides **cypermethrin** (£4.3M – 15%) and **thiacloprid** (£2.9M – 10%) the losses in scenario 2 would make asparagus production in the UK unviable for many growers.
- ***Beetroot*** (£12M – 43%) had already suffered reduction in disease control (**cyproconazole**, £4.9M – 18%) and pest control (**cypermethrin**, £2.7M – 10% and **thiacloprid**, £1.4M – 5%) in scenario 1, the additional loss of weed control (**triflusulfuron**, £2.7 – 10%) in scenario 2 is likely to make production unviable for the majority of growers.

The ***outdoor salad*** crop group is estimated to reduce in value by £101M – 35% of the sector farmgate value, in the absence of the active substances affected by scenario 2. The main impact is in a loss of disease control (£41M – 14%) with the loss of **mancozeb** being the most significant causing an estimated £23M – 8% reduction in farmgate value in scenario 1, with additional losses of **iprodione**, **prochloraz** and **difenoconazole** resulting in further reductions of control. In addition the losses of pest control would reduce value and yields by £31M – 11%, mostly as a result of the loss of **deltamethrin** (£27M – 9%). The combined loss of **linuron** (£14M – 5%) in scenario 1 and **propyzamide** (£15M – 5%) in scenario 2 would result in reductions in weed control (£30M – 10%) causing further challenges to maintaining viable outdoor salad production. The most severely impacted crops are expected to be ***celery*** (£17M – 55%), ***baby leaf brassicas*** (£5M – 51%) and ***lettuce*** (£68M – 48%). These crops are expected to be unviable for many growers to continue producing at current prices. There are an estimated 360 jobs associated with celery production, 250 jobs associated with baby leaf brassica production and 5,500 jobs

associated with lettuce production that would all be put at risk following the loss of the active substances in scenario 2.

Tree fruit are estimated to reduce in value by £71M - 36%, predominantly as a result of a reduction in pest control £37M - 19%, with the additional loss of **deltamethrin,** on top of actives lost in scenario 1, the main concern. In addition the loss of disease control is expected to reduce the value of the crop by £34M - 17%. The worst hit crop is ***pome fruit*** £58M - 41%.

The high quality specifications for ***ornamentals*** means that reduced disease control will result in the value of the crop group reducing by up to £199M - 16% and reduced pest control will account for a further reduction in value of £162M - 13%.

- **Hardy nursery stock** would reduce in value by an estimated £316M - 32%, whilst ***bedding and pot plants*** are estimate to reduce in value by £40M – 19%

Outside of the horticultural crops there would be large reductions in value of the ***hops and vines*** crop group (£14M – 65%) with a lack of disease control accounting for £7M – 32% of losses, with poor pest control accounting for a further £4M – 19% and reduced weed control £3M – 13%. ***Hops*** are particularly badly affected (£8M – 92%) as a result of the high quality specifications and low tolerance of pest or disease damage resulting in complete crop rejections. The combined loss of **myclobutanil**, **bupirimate** and **penconazole** means that there would be no approved active substances left for the control of powdery mildew. The UK hops crop could be completely wiped out as a result of the losses in scenario 2.

It is very important to note that British Hops is a long established niche crop for beer flavouring, standing apart from the commodity hop crop that is alpha-acid for bittering. As such, British hops are highly prized and brewers pay premium prices for continuing high quality. There is simply no place for anything other than high quality produce, and any estimate of economic farm-gate loss does nothing to account for the reduction in confidence for continuity of supply so crucial to brewers, to whom hops are a crucial yet very small part of their overall costs. Without hops there would be no British beer, and a number of sizeable UK breweries have founded their businesses on recipes using the Great British hop.

Sugar beet is estimated to reduce in value by £74M – 33% in scenario 2 as a result of reduced disease control (£38M – 17%) and reduced weed control (£35M – 16%), following the loss of **cyproconazole** (£28M - 12%), **difenoconazole** (£8.7M - 4%) and **triflusulfuron** (£35.4M - 16%).

Loss of yield in the ***oilseeds, pulses*** and ***potatoes*** is expected to be around 20-22% reducing the value of the crop by £150M - £47M and £193M respectively. The largest

losses in the oilseeds and potatoes are as a result of reduced weed control following the loss of **carbetamide** (£71M - 10%) and **propyzamide** (£71M - 10%) in oilseeds and **linuron** (£52M – 6%) and **metribuzin** (£137M – 15%) in potatoes. The losses in pulses are similar to those in scenario 1, with additional difficulties controlling resistant blackgrass populations following the loss of **propyzamide** (£2.7M – 1%) in ***field beans*** and ***combining peas***. The loss of **propyzamide** in both oilseeds and pulses and the loss of **carbetamide** in oilseeds would make the management of resistant blackgrass in the rotation very difficult as these active substances have no known resistance and are therefore valuable parts of a resistance management strategy. Blackgrass affected 40-50% of arable fields with most populations having resistance to older 'fop' and 'dim' ACCase herbicides and an increasing proportion having resistance to sulfonyl urea herbicides. A loss of control in the break crops would make it increasingly difficult to control this weed in cereals too without changes to the current farming practices and systems.

Scenario 3

In scenario 3 there are 29 additional active substances that have the potential to be defined as endocrine disruptors, but there is not currently enough information available on their characteristics to categorise them in either scenario 1 or 2. This group therefore has increased uncertainty over just how many of the active substances would be impacted. However, for the purpose of this assessment it is assumed that all active substances in this group, plus those in scenarios 1 and 2, are lost. The total reduction in farmgate value of the scenario across all 51 crops assessed is £3003M or 33% of the farmgate value. Edible horticulture accounts for £1168M which is 70% of the sector farmgate value. Ornamental horticulture accounts for £566M or 46% of sector farmgate value, other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) £1262M or 22% of sector farmgate value, and forestry £7M or 2% of forestgate value (Table 4).

Details of sectors and crop group impacts are shown in Table 11 and Table 12. These values are for yield impacts only and there are expected to be additional costs for mitigation options such as alternative active substances or changes in farm practice. Where impacts are significant it might also lead to some changes in land use and restructuring of the industry with consequences for jobs and investment in agriculture and the supply chain.

Losses to disease, weeds and pests have been looked at separately. When looked at separately there is the potential that a crop could suffer severe yield losses as a result of failed disease, weed or pest control. When combined if the losses from disease, weed or pest control failures exceed 100% it has been assumed that the whole crop will be lost and the value is defaulted to 100% of the crop value. No losses can exceed 100% of the value of the crop.

Table 11 **Value of yield losses by crop group for scenario 3, showing reduction in farmgate value of the sector (£M) and the percentage reduction in farmgate value (%) – edible horticulture and ornamental horticulture**

Scenario 3	All alliums	Field Vegetables	Outdoor salads	Protected edibles	Soft fruit	Tree fruit	Ornamentals
(ha)	12,290	49,147	14,295	830	9,723	19,147	5,000
(t)	425,100	1,306,650	226,770	174,860	146,691	547,292	0
(£M)	£116	£511	£289	£181	£374	£197	£1,243
Fungicides	£45	£136	£55	£23	£132	£34	£257
Herbicides	£31	£97	£67	£1	£69	£11	£94
Insecticides	£18	£167	£95	£25	£240	£64	£211
PGR	£0	£0	£0	£0	£0	£0	£0
All pesticides	£90	£386	£218	£47	£334	£109	£566
Fungicides	38%	27%	19%	13%	35%	17%	21%
Herbicides	27%	19%	23%	0%	18%	6%	8%
Insecticides	16%	33%	33%	14%	64%	33%	17%
PGR	0%	0%	0%	0%	0%	0%	0%
All pesticides	77%	76%	70%	26%	89%	55%	46%

Table 12 Value of yield losses by crop group for scenario 3, showing reduction in farmgate value of the sector (£M) and the percentage reduction in farmgate value (%) - other edible crops and forestry, and total for all crops

Scenario 3	Cereals	Oilseeds	Pulses	Potatoes	Sugar beet	Hops and vines	Forestry	Industry level
(Kha)	3,129	726	191	122	120	3	3,127	753
(t)	26,682	2,461	779	5,500	8,000	1	10,616	56,874
(£M)	£3,582	£693	£237	£900	£224	£21	£404	£8,968
Fungicides	£194	£102	£91	£5	£61	£15	£0	£1,149
Herbicides	£21	£144	£22	£189	£98	£6	£1	£851
Insecticides	£22	£0	£40	£1	£25	£12	£6	£926
PGR	£0	£0	£0	£226	£0	£0	£0	£226
All pesticides	£237	£246	£153	£421	£184	£21	£7	£3,003
Fungicides	5%	15%	38%	1%	27%	70%	0%	13%
Herbicides	1%	21%	9%	21%	44%	29%	0%	9%
Insecticides	1%	0%	17%	0%	11%	57%	1%	10%
PGR	0%	0%	0%	25%	0%	0%	0%	3%
All pesticides	7%	35%	65%	47%	82%	100%	2%	33%

The largest cause of yield losses in scenario 3 across all sectors is a reduced ability to control disease with loss of fungicides estimated to reduce the farm gate value by £1149M – 13% in reduced yields. Reduced pest control is expected to reduce value the value of the industry by £926M – 10% and a reduction in weed control is expected to reduce the farm gate value by £851M – 9% in reduced yields across all sectors. In addition the loss of **chlorpropham** as sprout suppressant in potato storage is expected to reduce the farmgate value of the ***potato*** crop by £226M as a result of an inability to store potatoes for prolonged periods.

The loss of active substances in scenario 3 is expected result in the complete loss (over 90%) of production in the following sectors ***alliums (leeks and salad onions), field vegetables (beetroot), outdoor salads (lettuce*** and ***spinach), protected salads (leaves*** and ***lettuce), soft fruit (strawberry)***, ***hops*** and ***vines***.

Although it would be possible to achieve some yield it is expected that the following sectors would also see large numbers of growers and farmers ceasing production due to the poor profitability of the crop and increased costs of production (reductions in value of 50-90%); ***alliums*** (***bulb onions*** £35M – 59%), ***field vegetables*** (***asparagus*** £18.7M – 65%, ***brassicas*** £215M – 77%, ***carrots*** £102M – 81%, ***courgettes and cucurbits*** £21M – 51%), ***outdoor salads*** (***celery*** £27M – 86%), ***soft fruit*** (***blackberry*** £7.2M – 87%; ***blackcurrant***

£6.0M – 51%; ***raspberry*** £77M – 86% and ***rhubarb*** £17M – 66%), ***tree fruit (cider apples*** £14M – 47% *and* ***pome fruit*** £87M – 61%*)*, ***pulses*** (***fresh beans*** £18M – 84%; ***fresh peas*** £51M – 88% and ***field beans and combining peas*** £85M – 53%), and ***sugar beet*** £184M – 82%. The figures assume that production will continue even at reduced yields, however it is likely that production of many of these crops will stop due to the difficulties in controlling weeds, pests and disease (unless alternative control methods can be found) so losses could be higher.

In ***potatoes*** the combined loss of herbicides (£189M – 21%) during production and the inability to store potatoes for long as a result of the loss of **chlorpropham -** £226M – 25%) plus more modest losses from reduced disease and pest control would result in a £421M – 47% reduction in the value of the crop . The lower yields will not support the current high cost base of potato production (seed, fertiliser, crop protection and machinery/storage) so it may result in restructuring of the industry and more significant reductions in production, particularly in the processing sector that relies on chlorpropham. This would also have impacts in the supply chain where jobs and investment in the UK would be at risk, although this is outside the scope of this study. For the processing sector there would be insufficient stored crop available to maintain production throughout the year, meaning that the processing businesses would be of questionable viability. Packers for the fresh retail market would also have increasing problems gaining access to sufficient high quality produce to meet demand. It is unlikely that this demand would be met through imports as those from Europe will also be impacted by the implementation of the legislation. Potatoes are large bulky items to transport and therefore widespread import of potatoes is not deemed to be viable for many businesses.

Impacts in **cereal** crops are relatively modest (£237M – 7%), however the loss of weed control in break crops such as **oilseed rape** and **field beans** could have rotational implications for cereal. This may require some changes in practices and land use in order to manage problem weeds such as blackgrass.

The impact of scenario 3 in the ***forestry*** sector is relatively small, however there will be impacts in the establishment of new plantations, which could affect management and yields in the longer term.

Under scenario 3 there would be serious impacts on the productive capability of UK growers, especially in the edible horticulture sector and some of the high value field crops such as **potatoes** and **hops**.

The Chartered Institute of Horticulture suggests that there are 37,000 jobs supported by the horticulture sector, many of those in rural areas of low employment. A high proportion of

these jobs could be impacted in the event of the losses in scenario 3. In addition to the jobs directly relating to the horticultural production of these crops, there are also jobs in related industries, agrochemical, fertiliser and material suppliers, processors and packers will all be impacted by a reduction in the viability of UK horticulture.

In the absence of the active substances in scenario 3 it is expected that horticultural and agricultural production in the UK would be severely impacted, with very few of our staple fruit and vegetable crops being viable to produce, and other crops becoming less profitable. Further analysis is required to establish the full impacts.

Key active substances

Scenario 1

In scenario 1 there are 17 active substances that are assumed to have a high risk of approvals being removed as a result of them being defined as endocrine disrupting substances. Two active substances were assessed to have no impact on any crop if they were lost, these were **maneb** and **ioxynil** (due to recent loss of approval and therefore exclusion from this assessment).

The active substances lost in scenario 1 that will have the largest impact on the agriculture, horticulture and forestry industries are summarised in Figure 2, with **abamectin, thiacloprid** and **linuron** having the largest individual impacts, although the loss of the combined fungicides is also significant. The breakdown of losses in the active substances with the largest impact is shown in greater detail in figure 3 and figure 4.

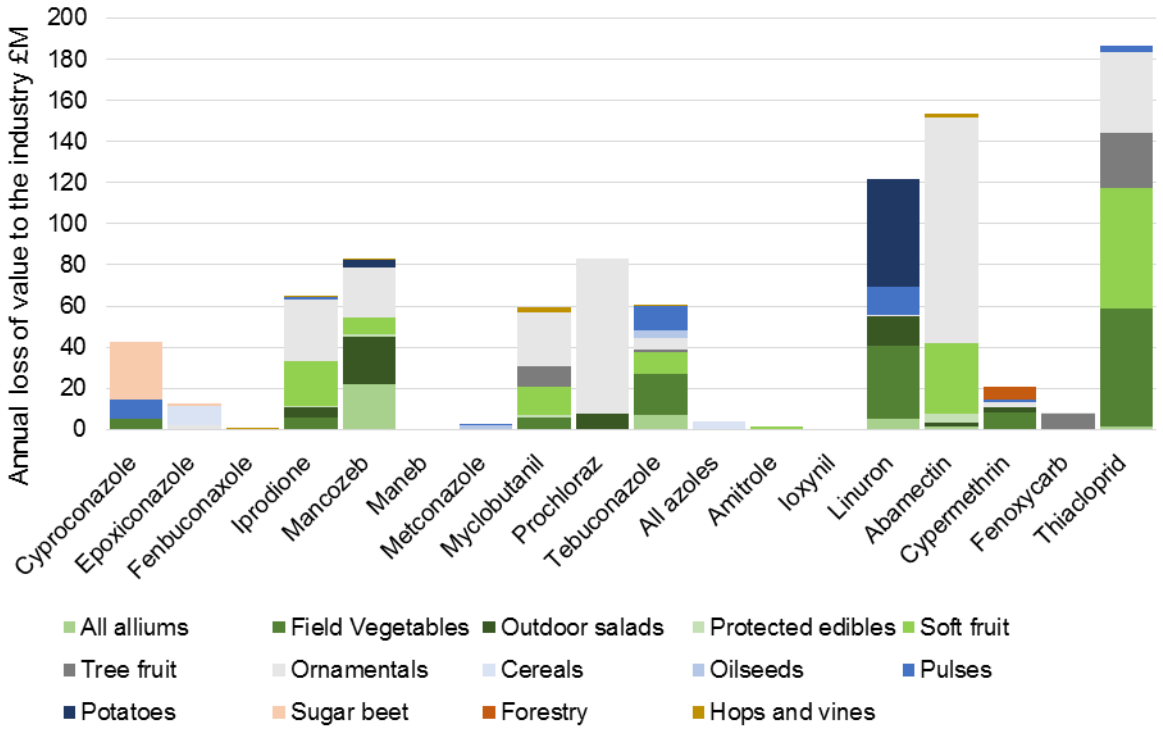

Figure 2 Impact of active substance loss in scenario 1 in lost value to the industry £M – Colours of the bars represent the crop groups impacted.

The loss of **abamectin** is estimated to reduce the value of the industry by £154M, predominantly as a result of a loss of mite control in ***ornamentals*** (£110M – 9%), but it also causes smaller losses on a further 11 crops.

Based on the expert returns, the loss of **thiacloprid** is expected to impact on 21 of the 51 crops assessed in this report. It is approved for use directly or through Extension of Authorisations to Minor Uses (EAMUs) for use in a wide range of crops including many 'minor' crops. It is an insecticide with a broad spectrum of activity including aphids, asparagus beetle, raspberry beetle, capsids and leaf miners, but a low persistence making it a suitable active for use in integrated pest management (IPM) plans. In scenario 1 the loss of this active would cause the greatest impact across the widest number of crops. The overall impact of its loss on the value of the industry is estimated at £187M. The largest impacts of losing thiacloprid would be felt in the ***field vegetable*** (£57M – 11%), ***soft fruit*** (£58M – 16%) especially ***strawberry*** (£41M – 19%), ***tree fruit*** (£27M – 14%) and ***ornamentals*** (£39M – 3%), crop groups. These crop groups have a low market tolerance of contamination or insect damage. In protected soft fruit there is also a high usage of Integrated Pest Management (IPM), so the loss of an important insecticide, thiacloprid, that is also compatible with IPM will have a significant impact on the profitability of production,

as alternative active substances are not as compatible with IPM and therefore a reduction in control of pests is expected.

The combined loss of fungicides in scenario 1 is estimated to reduce the farmgate value of the UK industry by £413M, in reduced yields. The loss of **prochloraz** (£83M) and **iprodione** (£65M) would mostly impact on the ornamental horticulture crops. Other impacts include;

- The loss of **mancozeb** has wider impacts, resulting in yield impacts on 14 crops at a value of £83M, with the largest impacts seen in ***ornamentals*** (£24M – 2%), ***alliums*** (£22M – 19%), ***outdoor salads*** (£23M – 8%), ***rhubarb*** (£8M - 31%) and ***potatoes*** (£3M - <1%).
- The loss of **myclobutanil** is estimated to reduce the industry value by £59M - affecting ***ornamentals*** (£27M – 2%), ***field vegetables*** (£6M - 1%), ***soft fruit*** (£14M – 4%) and ***tree fruit*** (£10M – 5%).
- In addition the loss of **tebuconazole** impacts on 16 of the crops, to a value of £60M per year. The largest impacts are in the following crop groups ***alliums*** (£7M – 6%), ***field vegetables*** (£20M – 4%), ***soft fruit*** (£10M – 3%) with the ***raspberry*** crop being particularly affected (£9M – 10%), ***tree fruit*** (£1.1M – 1%) and ***pulse crops*** (£12M – 5%).

The loss of herbicides in scenario 1 is estimated to decrease the value of the industry by £123M in reduced yields. The main source of this loss is the loss of **linuron** (£121M). Of the 51 crops assessed 11 were expected to suffer losses as a result of a loss of linuron, with the most severely affected crops being ***alliums*** (£1.5M – 5%), ***field vegetables*** (£35M – 7%) especially ***carrots*** (£33M – 26%), ***outdoor salads*** (£14 – 5%) especially ***celery*** (£9M – 30%), ***pulses*** (£14M – 6%) and ***potatoes*** (£52M – 6%).

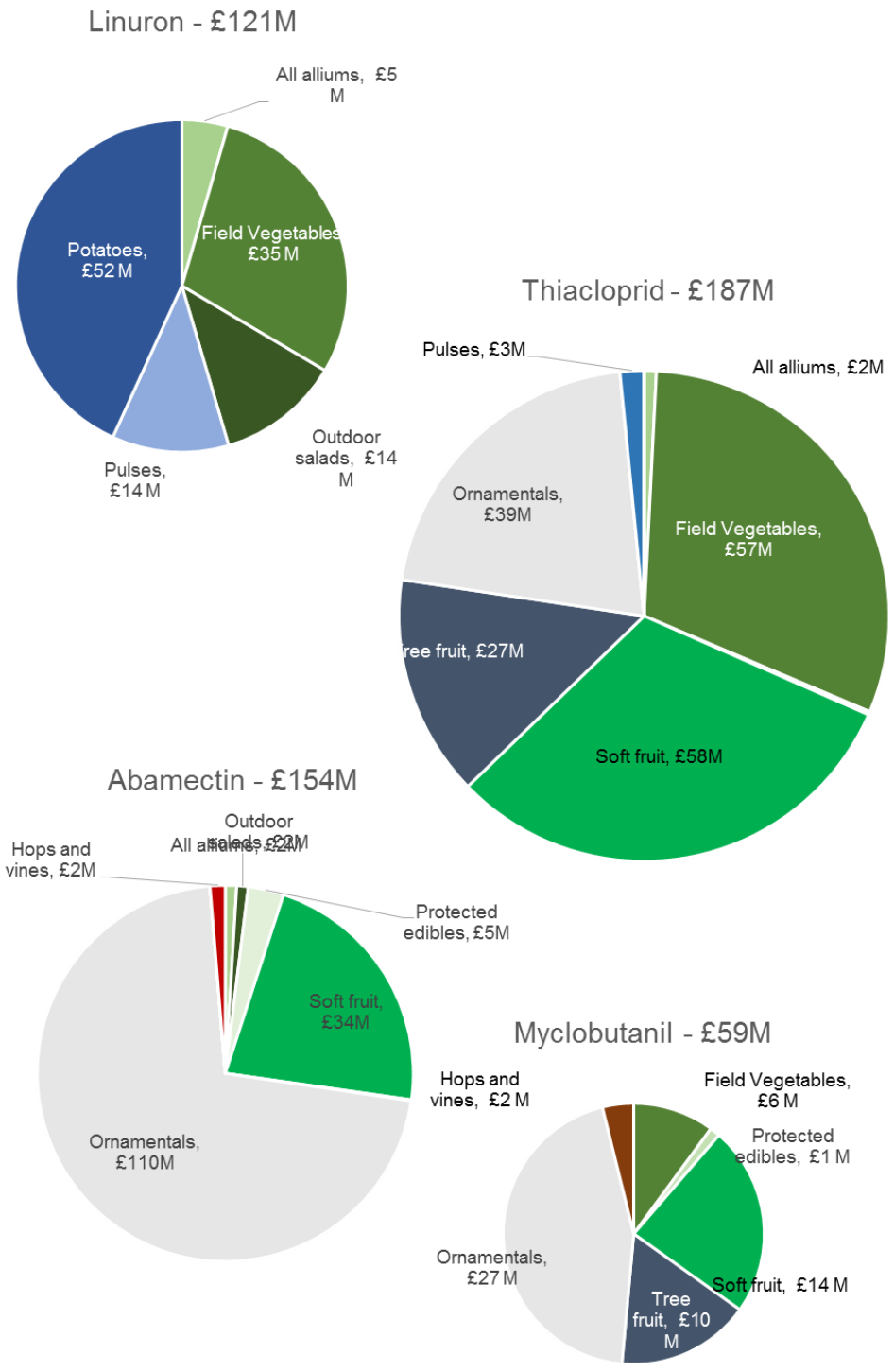

Figure 3 Impact of active substance loss in scenario 1. Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts.

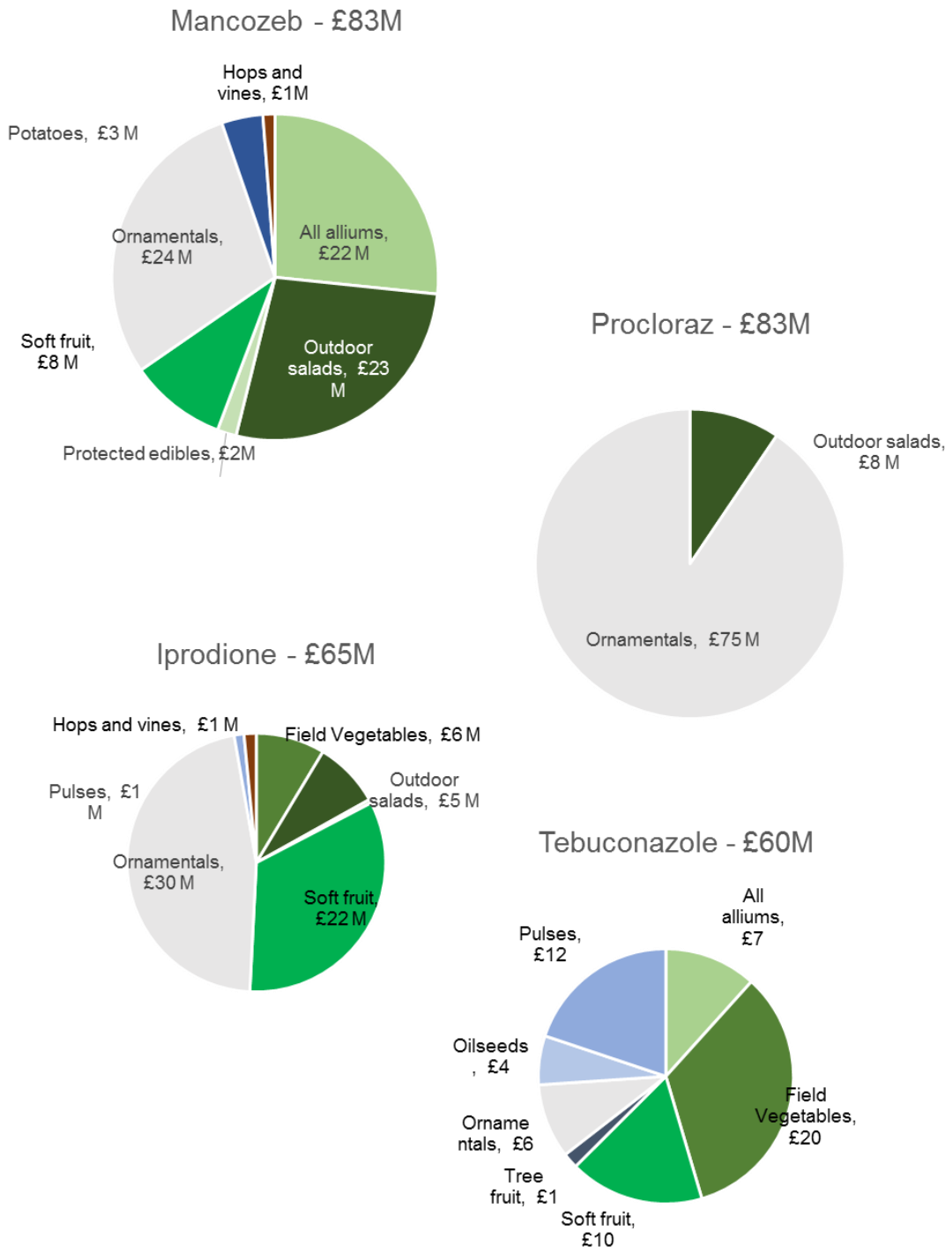

Figure 4 Impact of active substance loss in scenario 1. Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts.

Resistance management

Although in the first scenario the majority of crop groups will manage to maintain production, albeit at lower margins, the loss of any active substance has the potential to reduce the effectiveness of resistance management strategies. For example the loss of the multisite fungicide active **mancozeb** from blight programmes in potatoes and disease management strategies in other crops could have a significant impact on the resistance status of target pathogens. Farmers and growers will have to use more applications of fewer active substances, often with single site modes of action. In many crops these active substances are currently only approved for use alongside a multisite active, to try and reduce the risk of resistances developing to their mode of action. The loss of mancozeb, and some of the other fungicides means that for some crops farmers and growers will be unable to follow FRAG (Fungicide Resistance Action Group) guidelines in the application of fungicides. This means that there is an increased risk of resistance developing more quickly to the remaining active substances, further reducing the level of control in future years as resistance develops. .

Comparison with previous work

Previous work completed by FERA and ADAS[7] used a slightly different methodology to calculate the impacts of losing certain potential endocrine disrupting active substances on the industry. It looked at both the yield impact and the cost of alternative control options to provide an impact of loss, the groups of active substances lost in the various scenarios were not identical, with fewer active substances lost in the FERA work than are assumed in this latest assessment, therefore it is expected that the losses in this assessment would be slightly higher than those of the FERA work. The crop groups looked at were similar, but not identical to this work, so there is not always direct read across and the base years for crop areas and values differ too. The results from the FERA study for the key active substances are summarised in Table 13.

[7] Jones G, Garthwaite D, Wynn S, Twining S (2013) Agronomic and economic impact assessment for possible human health and ecotoxicology criteria for endocrine disrupting substances. Report to CRD

Table 13. Impacts calculated in FERA report – group 1 more likely to pose a risk – Only these 5 active substances were assumed to be lost in this scenario.

Active substance	Crops	Impact	Comment
Mancozeb	Brassicas, bulbs, grapevine, herbs	£81,000	No yield impact – just additional cost of production
Ioxynil	Onions (dry bulb), onions (salad), leeks	£40,800,000	Yield impacts of 20-40% and increased cost of production
Linuron	Carrots, celeriac, celery, French beans, herbs, onions (dry bulb), leeks, parsnips, potatoes	£117,400,000	Wide range of yield impacts up to complete crop loss, increase in cost of production
Abamectin	Blackberry, ornamentals, hops, leeks, strawberry		Impacts on quality, harvestability or complete crop rejection – not quantified
Thiacloprid	Ornamentals, blackcurrant, brassicas, OSR, raspberry, seed potatoes, strawberry, wheat, apples		No predicted yield impacts and minimal increase in costs, alternatives remain that provide adequate control

Losses were calculated for **ioxynil** in the FERA assessment, whilst it has been excluded from the current assessment due to its recent withdrawal. **Mancozeb** was deemed to have no real impact on yield in the 4 crops included in the FERA work, but there was an increased cost of production, whilst in the latest assessment an £83M reduction in farmgate value was estimated across 15 different crops. The losses for **linuron** are similar across the two assessments allowing for slight differences in the crops assessed. In the FERA work no impacts were allocated to **abamectin** or **thiacloprid** however, in combination with the other actives lost in the current assessment it was considered by the experts that there would be high yield losses.

Scenario 2

In scenario 2 there are 20 additional active substances that are assumed to have a lower risk of approvals being removed as a result of them being defined as endocrine disrupting substances. Eight of these active substances were assessed to have no impact on any crop if they were lost, these were **folpet, fuberidazole, propiconazole, tetraconazole, triademenol, triticonazole, chlorotoluron** and **fluometuron**, although it should be noted that the combined loss of azoles might have impacts on certain crops (e.g. cereals and oilseeds) that have not been allocated to individual active substances instead they were grouped under all azoles (Figure 5).

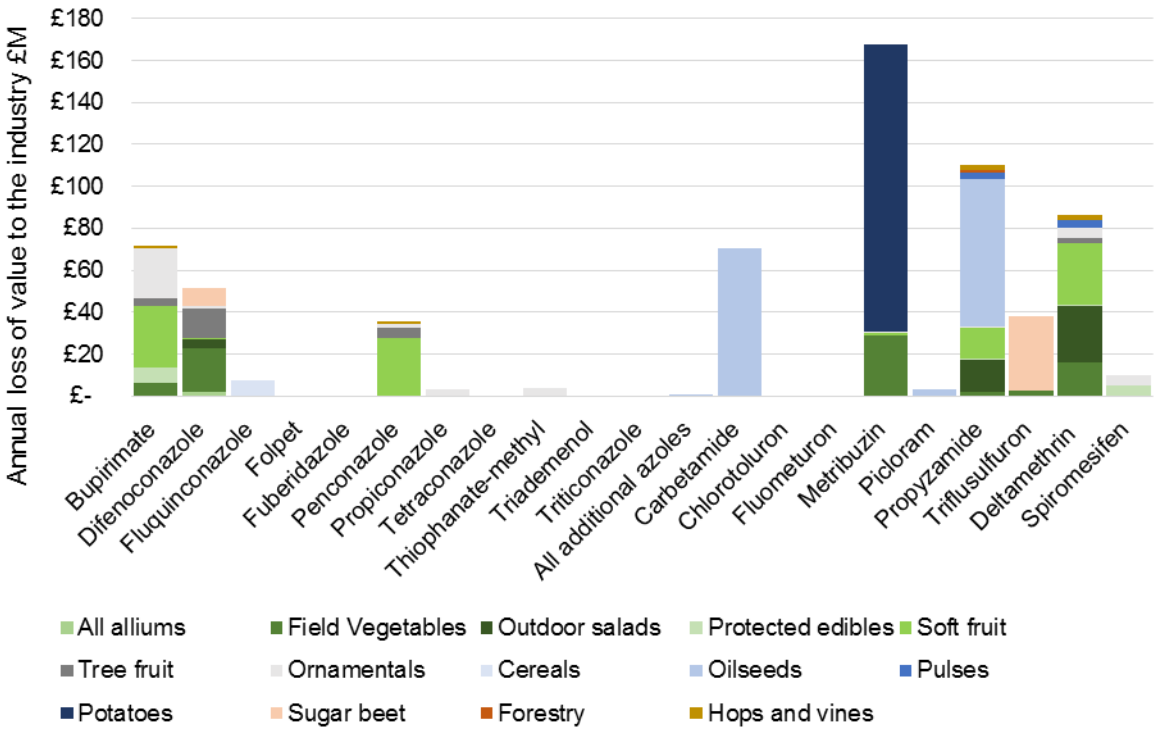

Figure 5 Impact of active substance loss in scenario 2 in lost value to the industry £M – Colours of the bars represent the crop groups impacted.

The active substances that will have the largest impact if lost are the herbicides with the loss of **metribuzin** estimated to reduce value by £167M - affecting 5 of the 51 crops, and **propyzamide** estimated to reduce value by £110M affecting 16 of the crops. The loss of **deltamethrin** (£86M) affecting 18 crops would also have large yield implications (Figure 5).

The largest impact from the loss of **metribuzin** is in ***potatoes*** (£137M – 15%) making broad-leaved weed control on organic soils particularly difficult, with certain weeds that would have no chemical control options left. Where mechanical weeding is required to optimise yields in the absence of chemical control there would be large increases in costs and loss of quality (not captured here). Loss of metribuzin would also impact on weed control in ***asparagus*** (£3.4M – 12%), ***carrots*** (£25.3M – 20%) and ***blackcurrants*** (£1.1M – 9%).

The loss of **propyzamide** and **carbetamide** would have severe implications for the control of resistant blackgrass in arable rotations, with yield losses in ***oilseed rape*** of £71M – 10% attributed to each across the whole crop, resulting in total losses of £142M – 20%. Blackgrass affects about 40-50% of arable fields and resistance is widespread. Propyzamide and carbetamide provide useful alternative modes of action to those available for use in cereal crops, with no known resistance. Therefore the use of these active substances is an important part of the rotational management of resistant blackgrass. The loss would have wider implications beyond the oilseed rape crop as higher seed returns

following poor control would increase weed burden in following crops, these additional impacts are not captured within this assessment.

The loss of **propyzamide** would also impact on another 15 crops including ***courgette and cucurbits*** (£2M – 5%), ***baby leaf brassicas*** (£0.9M – 10%), ***lettuce*** (£21M – 10%), ***protected salad leaves*** (£0.1M – 7%), ***protected lettuce*** (£0.8M – 6%), ***vines*** (£2.5M – 21%) and ***forestry*** (£1.3M – 0.3%).

The other important herbicide lost in this scenario is **triflusulfuron** (£38M) which although it only impacts on one crop, is very important in ***sugar beet*** (£35M – 16%) for weed control.

After the herbicides the next most important active lost is the insecticide **deltamethrin** (£86M). The loss of this active results in yield losses in 18 of the 51 crops. The main crop groups and crops impacted are the ***outdoor salads*** (£27M – 9%) especially ***lettuce*** (£21M – 15%) and ***spinach*** (£1.9M – 15%), the ***soft fruit*** (£29M – 8%), ***tree fruit*** (£2M – 1%), ***ornamental horticulture*** (£5M – <1%) and ***hops*** (£2M – 21%). In the ***soft fruit*** crop group and ***tree fruit*** (***stone fruit)*** there is the potential for the importance of this active to increase in response to the increasing threat from spotted winged drosophila. This pest is a relatively new pest in the UK, but has the potential to cause massive yield losses if left uncontrolled. Deltamethrin will be an important tool for the control of this pest.

There are also three fungicides lost in this scenario that will have large impacts on certain crop groups. The loss of **difenoconazole** (£51M) would result in yield losses from 11 different crops. The largest losses would be in the ***alliums*** especially ***leeks*** (£2.2M – 7%), ***field vegetables*** (£20M – 4%) especially ***asparagus*** (£1M – 5%), ***brassicas*** (£14M – 5%) and ***carrots*** (£5M – 4%), ***outdoor salads*** - ***celery*** (£5M- 15%), ***tree fruit*** - ***pome fruit*** (£14M - 10%) and ***sugar beet*** (£9M – 4%).

The loss of **bupirimate** (£72M) would result in yield losses across eight different crops, this active is important in powdery mildew control and when combined with the loss of **myclobutanil** in scenario 1 leaves few effective alternatives in these crops. The worst affected crops are ***courgettes and cucurbits*** (£6M – 15%), ***cucumber*** (£8M – 15%), ***strawberries*** (£28M – 13%), ***pome fruit*** (£3.6M – 3%) ***hardy nursery stock*** (£24M - 2%) and ***hops*** (£1M – 5%). The loss of **penconazole** (£47M) would impact on 6 crops, with the largest losses in ***strawberry*** (£28M – 13%), ***pome fruit*** (£3.6M – 3%), ***hardy nursery stock*** (£1.2M - <1%) and ***hops*** (£1M – 5%).

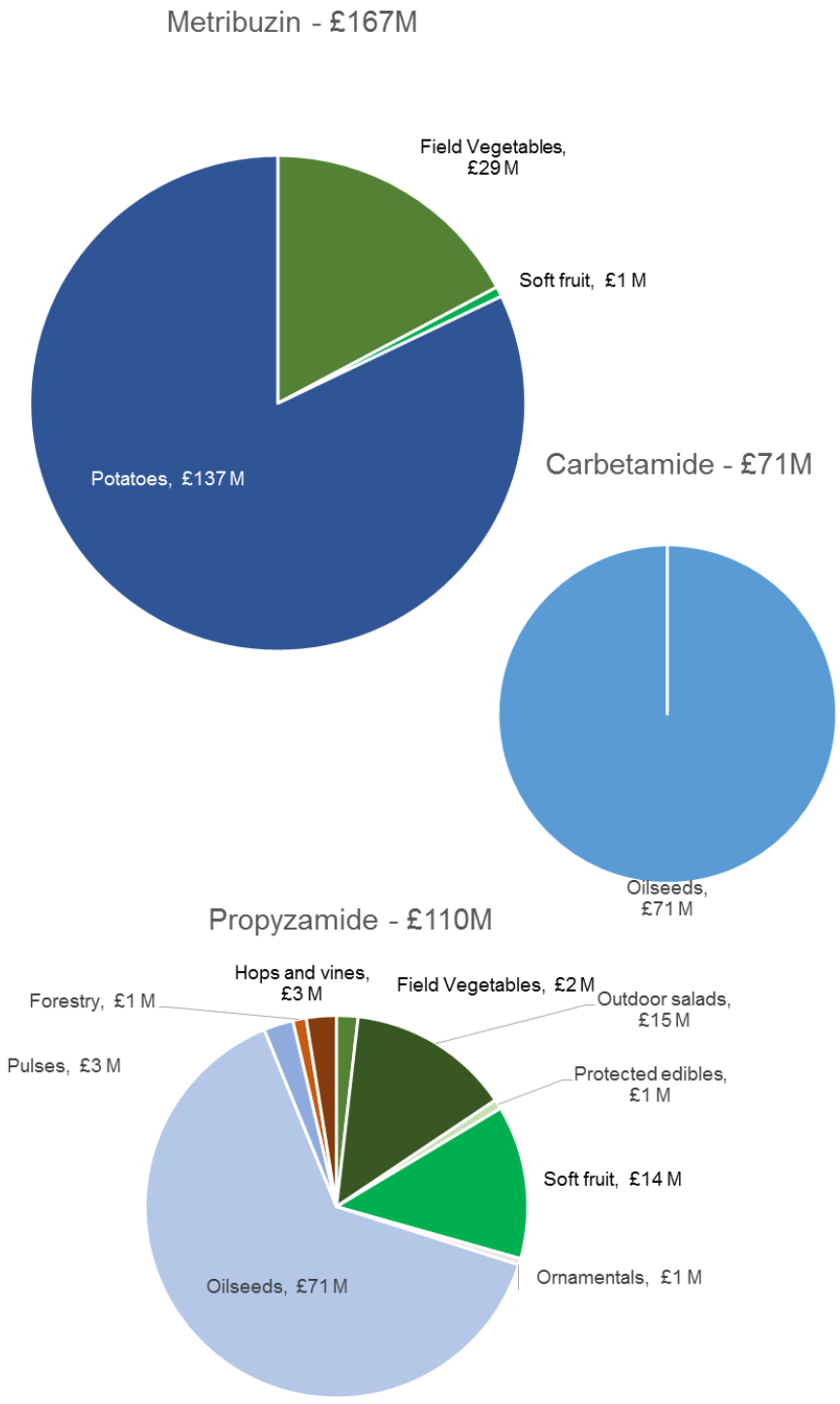

Figure 6 Impact of active substance loss scenario 2 (impacts over £50M). Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts.

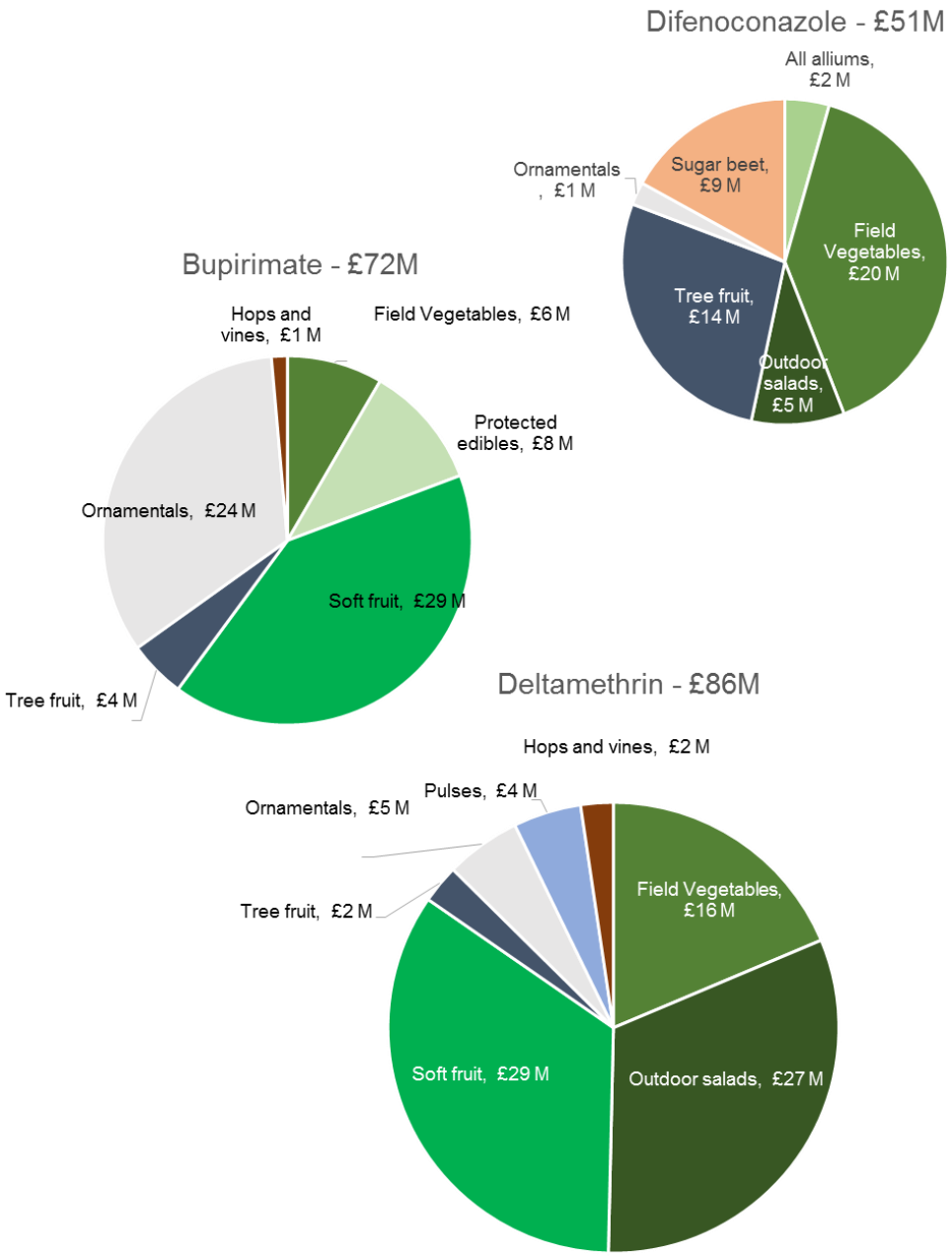

Figure 7 Impact of active substance loss scenario 2 (impacts over £50M). Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts

Comparison to previous work

In the FERA/ADAS work identified above a second scenario assessed the impact of a loss of further active substances, including some that are in the scenario 2 list assessed in this report. The results from these assessments are summarised in Table 14. The largest impacts in the FERA assessment were from the loss of **metribuzin** (£80M) across carrots, asparagus, bulbs and potatoes, with a 10% yield loss assumed in potatoes. In the current

assessment the losses from metribuzin (assuming linuron was lost in scenario 1) are estimated to be £167M - for five crops including potatoes, which were assumed to suffer yield losses of 15%. The next largest losses in the FERA report are for **tebuconazole** at £53M - across 9 crops), which is consistent with the current report at £60M - across 16 crops). **Bupirimate** was estimated in the FERA report to be worth £23M across 3 crops, whilst the current report increases its value to £72M across 8 crops including ***pome fruit*** and ***hardy nursery stock***, and yield losses to ***strawberry*** of 13%. Some differences in impact will be down to the different price of crops in each assessment. Losses for **propyzamide** are lower in the FERA assessment because the scenario assumed that **carbetamide** remained available for use in ***oilseed rape*** and would be used as a partial replacement.

Table 14 Impacts calculated in FERA report – group 1 less likely to pose a risk – Only these active substances were assumed to be lost in this scenario, plus the five high risk active substances in Table.

Active substance	Crops	Impact	Comment
Bupirimate	Cucurbits, hops, strawberry	£23,000,000	10-30% yield impact
Iprodione*	Ornamentals, vines	£1,200,000	Yield impacts of 10%, plus additional cost of production
Myclobutanil	Blackcurrant, cucumber, grapevine, ornamentals, pears, strawberry		Minimal yield impacts
Prochloraz	Ornamentals, linseed, oilseed rape, wheat	£3,700,000	Minimal yield impacts, but increase in cost of production
Tebuconazole	Brassicas, bulbs, carrots, leeks, onions (salad), OSR, raspberry, field beans, wheat	£53,000,000	Modest yield loss, increased cost of production
Thiophanate-methyl	Ornamentals, oilseed rape, tomato, carrots		No impacts identified
Metribuzin	Asparagus, bulbs, carrots, potatoes	£79,800,000	Yield impacts of 10% in potatoes, increase in costs
Propyzamide	Ornamentals, Christmas trees, hops, lettuce, radicchio, raspberry, strawberry	£31,300,000	Yield impacts of 0-25% (Carbetamide still assumed to be available in OSR)
Spiromesifen	Ornamentals, strawberry, tomato		No impacts calculated

* Actually in our scenario 1

Scenario 3

In scenario 3 there are 29 additional active substances at risk those that are expected to impact on UK agriculture, horticulture or forestry are shown in (figure 8). There are three active substances which were assessed to have no impact on any crop if they were lost, these were **2,4-D**, **pinoxaden** and **malathion**.

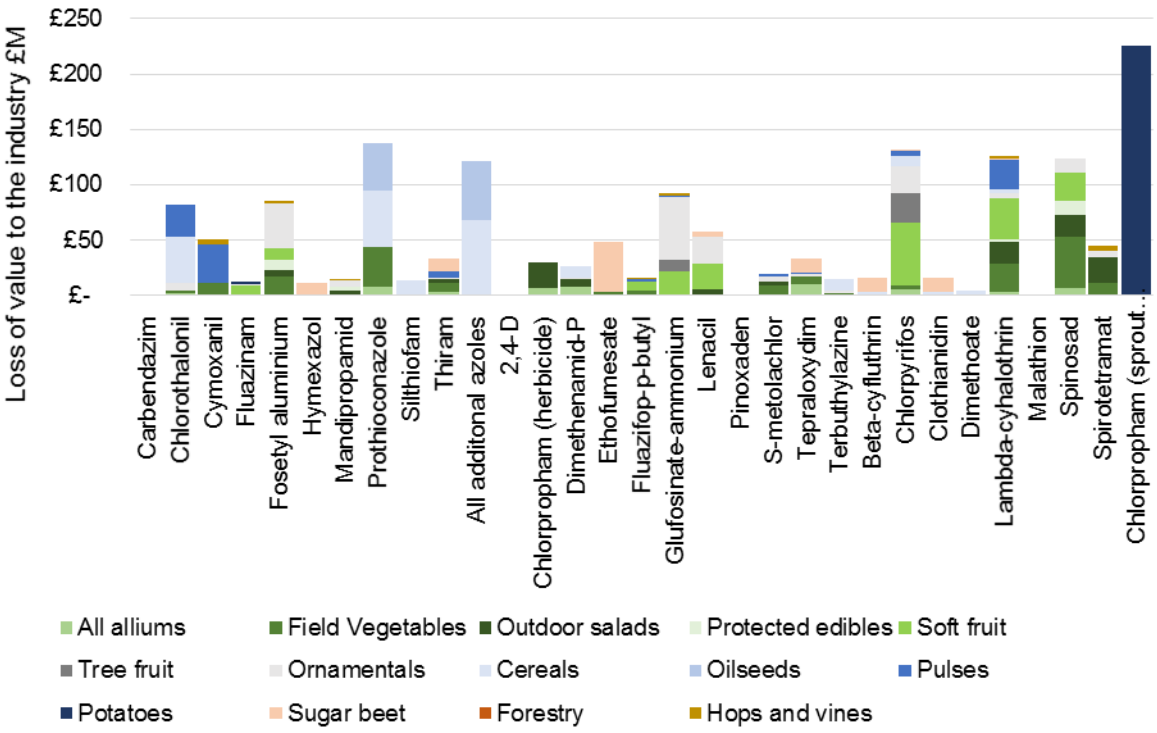

Figure 8 Impact of active substance loss in scenario 3 in lost value to the industry £M – Colours of the bars represent the crop groups impacted.

The active that would have the single biggest impact if lost in this scenario is **chlorpropham,** £226M as a sprout suppressant, plus £30M as a herbicide) see Figure 9.. The largest loss would occur in the ***potato*** crop where it is used as a sprout suppressant during medium and long term storage. If it were not available it would become almost impossible to store potatoes for long periods, especially those crops destined for a processing market where it is not possible to use low temperatures to minimise sprouting. The loss of chlorpropham is estimated to reduce value by the potato crop £226M – 25%, with increased uncertainty over supplies for certain periods of the year. Chlorpropham is also used as a herbicide in the ***alliums*** (£7M – 6%) and ***outdoor salads*** (£23M – 8%) - especially ***lettuce*** (£21M – 15%).

It is the loss of fungicides and resultant disease control that will have the largest impact on the industry, resulting in the industry value reducing by £1149M.

The largest loss in this scenario would be the loss of **prothioconazole** (£138M) and the other ***azoles*** (£121M) resulting in reduced disease control, especially in the ***cereals*** (£51M – 1% and £68M – 2% respectively), but also in the ***oilseeds*** (£43M – 6% and £53M – 8% respectively). Loss of prothioconazole would also impact on disease control in ***alliums*** (£8M – 7%) and ***field vegetables*** (£36M – 7%) especially ***brassicas*** (£31M – 11%) and ***carrots*** (£5M – 4%).

The loss of **fosetyl aluminium** would reduce the value of the industry by £85M, predominantly as a result of its impact on disease control in ***ornamentals*** (£40M). Whilst the loss of **chlorothalonil** would reduce the value of the industry by £81M, with the main impacts in ***cereals*** (£41M) and ***pulses*** (£29M).The loss of **chlorpyrifos** (£131M) would result in yield losses from 22 crops and have the greatest impacts on ***alliums*** (£6M – 5%), ***soft fruit*** (£56M – 15%) especially ***blackberry*** (£2M – 25%), ***blackcurrant*** (£3M – 21%), ***raspberry*** (£18M – 20%) and ***strawberry*** (£33M – 15%), ***tree fruit*** (£27M - 14%) and ***ornamentals*** (£24M - 2%),

The loss of **lambda-cyhalothrin** (£126M) would result in yield losses from 28 of the crops and have the greatest impact on ***beetroot*** (£3M – 10%), ***brassicas*** (£14M - 5%), ***carrots*** (£9M – 7%), ***outdoor salads*** (£20M – 7%), ***soft fruit*** (£37M – 10%) especially ***blueberries*** (£2.8M – 19%) and ***strawberries*** (£33M – 15%), ***ornamentals*** (£5M – <1%), ***pulses*** (£26M – 11%), ***hops*** (£2M – 22%) and ***vines*** (£1M – 8%).

The loss of **spinosad** is estimated to reduce the value of the industry by £124M and would result in yield losses from 22 of the crops as a result of reduced pest control in ***alliums*** (£7M - 6%), ***field vegetables*** (£46M - 9%), ***outdoor salads*** (£20M - 7%), ***protected edibles*** (£13M - 7%), ***soft fruit*** (£25M – 7%) and ***ornamentals*** (£13M –1%),.

The loss of the herbicide **lenacil** would reduce the value of the industry by an estimated £57M, predominantly as a result of the impact on ***soft fruit*** (£24M - 6%) and ***ornamentals*** £24M – 2%.

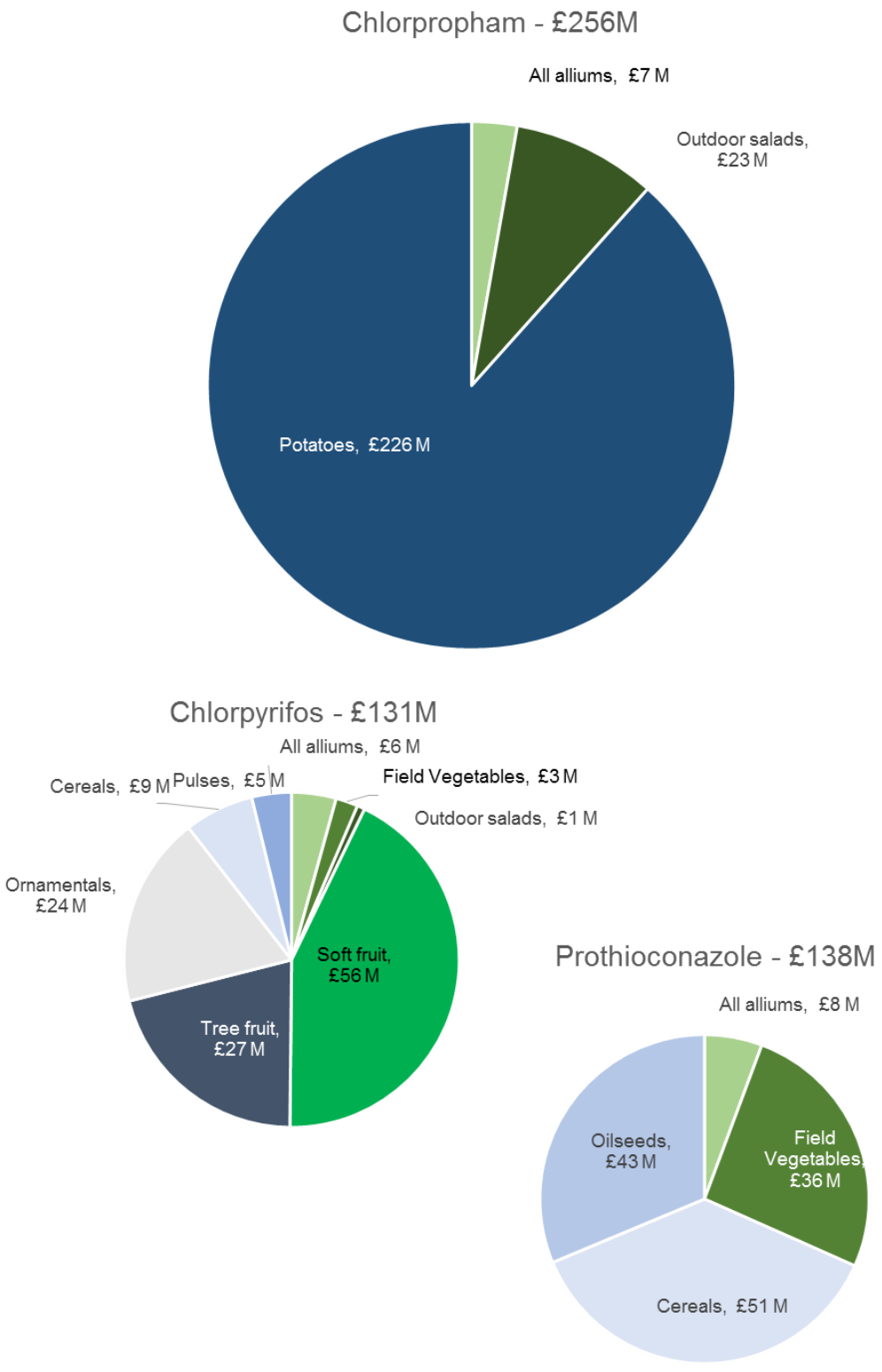

Figure 9 Impact of lost active substances in scenario 3 (impacts over £50M). Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts

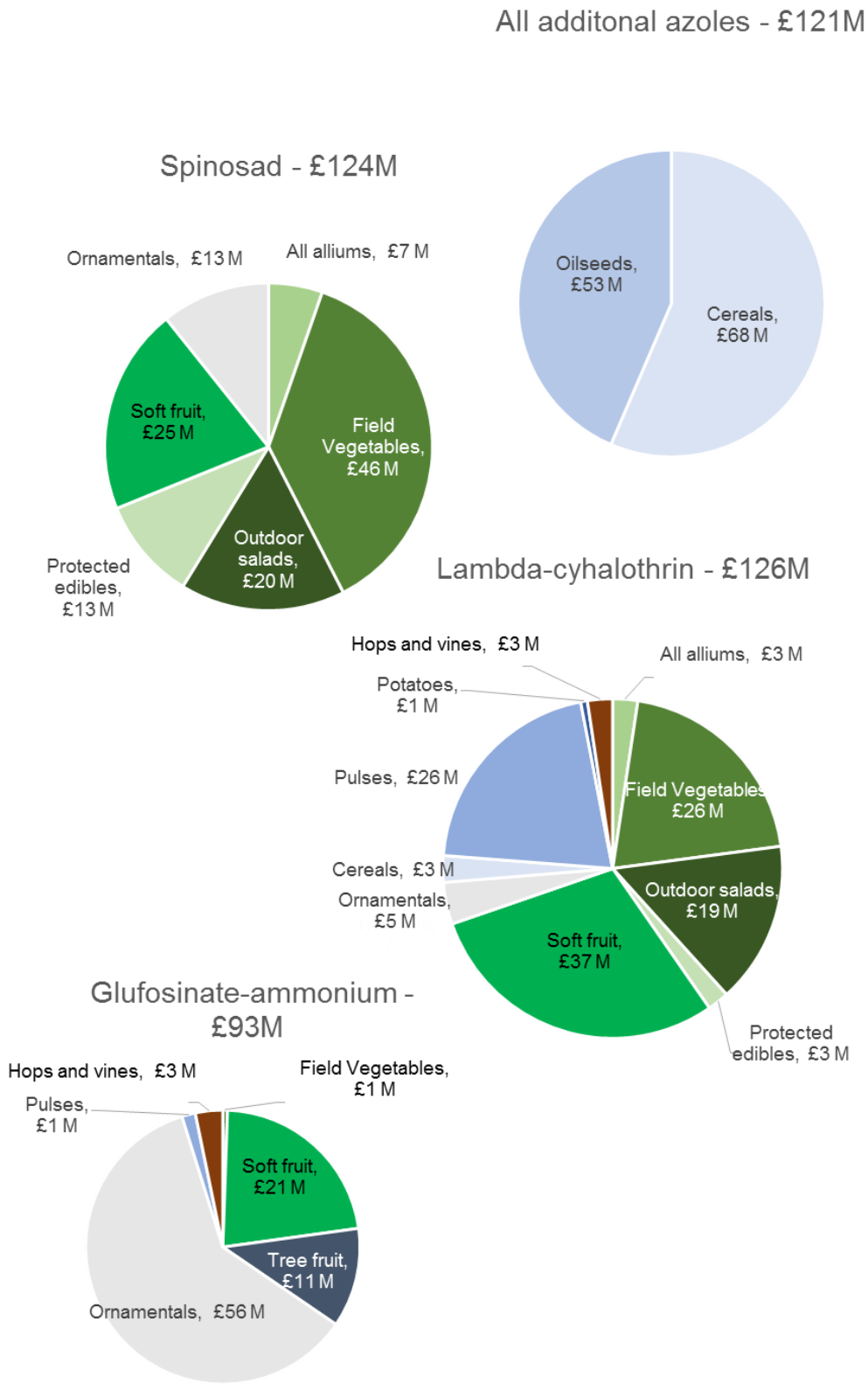

Figure 10 Impact of lost active substances in scenario 3 (impacts over £50M). Size of pie represents the total impact across all crop groups, whilst the individual slices represent the crop group level impacts.

Conclusions

Industry perspective

Impact on production: The farmgate value of lost production calculated in this report highlights the potential economic impact on farmers, and demonstrate the likely change in production levels. The yield losses in scenario 1 (most likely active substances to be lost) across the edible crops are equivalent to a 2.4M tonne reduction in food production, in scenario 2 this rises to 5.7M tonnes and in scenario 3 the losses could equate to 14.2M tonnes. This compares to an estimated total UK production from these crops of 46.3M tonnes so represents a significant change in productive capacity.

Uncertainty: A key factor in the impact is the final definition of what an endocrine disruptor is, and whether further work will result in the inclusion of others that are currently uncertain due to lack of information. However, there is a degree of certainty over scenario 1, with impacts on the industry estimated to be £905M or 10% of the farmgate value. The uncertainty of inclusion of active substances in scenarios 2 and 3 mean that the worst case may not be realised, however the estimated losses of up to £3003M is equivalent to 33% of the farmgate value and will be very serious for many sectors of the food production industry.

Timescales: There is an assumption in each of the scenarios that all the actives will be withdrawn at the same time in the near future, which will not allow any time for the development of alternative approaches, or for the market to adjust, however at least for scenarios 2 and 3 losses are expected to be more staggered (see section below).

Other impacts. This assessment looks at the impact of loss of active substances on marketable yield, and the value of the crop. There are a range of other potential impacts that are outside the scope of this report and would require further work to quantify, these include;

- *Crop viability*. Loss of marketable yield has an impact on the crop economics, and this is one aspect of decisions on crop viability. Decisions on which crop to grow will depend on a range of factors including market prices, costs of production and expected yields, as well as alternative options. The point at which a crop becomes unviable will vary for different crops and production systems. This report has taken coarse cut off points of 50% reduction in value and 33% reduction in value to give an indication of the scale of the impacts. These do not relate to the potential viability of the business. In a crop where profit margins are small, e.g. some of the vegetable crops, any reduction in value could severely impact on the viability of the crop enterprise.

- *Business viability*: For some, the loss of marketable yield could be a threat to business viability, particularly on smaller holdings with fewer alternative options. This is particularly the case where businesses have very specialised infrastructure, or capital investment, targeted at particular crops or groups of crops they could be more vulnerable to the loss of active substances within their crop as their ability to switch to alternative crops will be compromised.
- *Adaptation.* Farmers and growers will take mitigating actions to minimise any potential yield loss, such as using alternative active substances where available, modifying their production systems or using new technology. Adoption of simple, currently available measures (such as alternative active substances) have been included in calculation of the yield impacts, however their costs have not been included. There could also be potential to maintain yields through more complex changes to production systems, but these have not been assessed.
- *Resistance* – All good crop protection strategies take into account resistance management and is supported by a range of groups WRAG, FRAG etc. These involve using a range of active substances with different modes of action. Any loss of active substances, especially those with unique modes of action, or multi-site activity, is likely to compromise resistance management strategies. A reduction in the available pesticide active substances could therefore result in target species becoming resistant to the remaining active substances resulting in further yield impacts in the medium to long term (5-10 years). Blackgrass in cereals and oilseeds, and blight control in potatoes are particular issues.
- *Organic production* – A number of the crops assessed in this report can be produced organically, indicating that with the right management practices and infrastructure in place it is possible to produce crops without the use of plant protection products. However organic production has a higher cost base and lower yields than conventional production, and relies on a premium for organic produce for profitable production. Any comparisons need to understand the market impacts and consumer demands.

Sector variations

The largest impacts are expected in the sectors where there are limited pesticide active substances available, and therefore fewer potential alternatives available in the event of losing and active substance.

- The horticultural sectors (edible and ornamental) are severely affected, with the added challenge of high quality specifications for produce resulting in higher reductions in marketable yield.

In the event of the actives in scenario 1 – those most likely to be defined as endocrine disruptors – being lost the production of horticultural crops in particular will be impacted, with reduced yields affecting many crops. There will be a number of staple fruit and vegetable crops in particular that will become uneconomic to produce, limiting the ability of the UK to produce certain types of fresh produce.

- Industry level impact of mostly likely active substances being lost – scenario 1 £905M or 10% of farmgate value Edible horticulture would reduce in value by £431M or 26% Ornamental horticulture would reduce in value by £317M or 26%
    - Other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) would reduce in value by £151M or 3%. Forestry would reduce in value by £6M or 1% - challenges establishing new plantations In the event

of the active substances in scenario 2 – those less likely to be defined as endocrine disruptors – being lost the production of horticultural crops in particular will be severely impacted, with reduced yields affecting most crops.

- Industry level impact of the losses in scenario 2 is expected to be £1567M or 17% of farmgate value.
    - Edible horticulture estimated to reduce in farmgate value by £697M or 42%
    - Ornamental horticulture estimated to reduce in farmgate value by £364M or 29%
    - Other edible crops (cereals, oilseed, pulses, potatoes, sugar beet, hops and vines) estimated to reduce in farmgate value by £498M or 9%
    - Forestry estimated to reduce in forestgate value by £7M or 2% of forestgate value.
- Over 50%; ***leeks, asparagus, baby leaf brassicas, celery, protected salad leaves, rhubarb, strawberry,*** and ***hops***.
- Over 33% ; ***salad onions, beetroot, lettuce, blackberry, raspberry, pome fruit, Sweet Williams (cut flowers), sugar beet*** and ***vines***.
- Increasingly difficult to produce ***potatoes*** profitably
- Loss of **propyzamide** and **carbetamide** will reduce effectiveness of blackgrass control in ***oilseed rape*** and ***field beans*** potentially requiring large scale changes in rotation and active substances used on affected farms.
- The five most important active substances (by value of lost yield) affected in scenario 2 are **metribuzin** (£167M, especially in potatoes), **deltamethrin** (£86M)**, propyzamide** (£110M), **carbetamide** (£71M) and **bupirimate** (£72M).

In the event of the actives in scenario 3 – those for which there is insufficient data – being lost the UK horticulture sector would become unviable with complete loss of production of

most crops, or such a high level of yield loss that the expectation is that crop enterprises would cease production. It would be almost impossible for the UK to produce high quality, affordable fruit and vegetable crops.

- The industry level impact of the losses in scenario 3 is £3003M or 33% of the industry farmgate value.
- Edible horticulture estimated to reduce in farmgate value by £1168M - 70%
- Ornamental horticulture estimated to reduce in farmgate value by £566M or 46%
- Other edible crops (cereals, oilseeds, pulses, potatoes, sugar beet, hops and vines) estimated to reduce in farmgate value by £1,262M or 22%
- Forestry estimated to reduce in forestgate value by £7M or 2%.
- Over 50% reduction in value expected in; bulb onions, leeks, salad onions, asparagus, beetroot, baby leaf brassicas, carrot, courgette and cucurbits, baby leaf brassicas, celery, outdoor lettuce, spinach, protected salad leaves, protected salads lettuce, blackberry, blackcurrant, raspberry, rhubarb, strawberry, pome fruit, , fresh beans, fresh peas, other pulses, sugar beet, hops and vines.
- Over 33% reduction in value expected in; protected peppers, cider fruit, stone fruit, bedding and pot plants, bulbs and outdoor cut flowers, hardy nursery stock, oilseed rape and potatoes.
- Potatoes could not be stored and weed control would be almost impossible making this crop unviable

Timescale of impacts

There are a number of options and categories that have been set out by the EU[8] in a roadmap for developing the definitions of endocrine disruptors. Our scenarios align with the categories set out in the roadmap. The road map indicated that those active substances that fall into category 1 (our scenario 1) are most likely to be lost. Those that fall into categories 2 or 3 (our scenario 2 or 3) would potentially be seen as early warnings to the industry that action needs to be taken to verify the safety of these active substances. Therefore, the indications are that depending on the outcome of the consultation those active substances that have clear endocrine disrupting functions (scenario 1) will be lost, probably within a fairly short timescale of the decision being made, however those that fall into the other categories (scenarios 2 and 3) are likely to require more investment in the development of evidence to demonstrate whether or not they are safe to use. This process will take time and money, some active substances will not be supported by their

[8] http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2014_env_009_endocrine_disruptors_en.pdf

manufacturers if the cost is too great or they expect the evidence not to support the approval of the active substance, whilst others will take time to go through the process, so the expectation is that losses of active substances in these scenarios will be staggered, rather than all occurring at once as assumed in this study.

A public consultation was launched in 2014 and it is expected that a decision on the final definition of endocrine disruptors will be made following the conclusion of the consultation in 2015.

Wider implications

The loss of pesticide active substances is likely to have implications beyond the farm gate, these have not been assessed in this report but a number of areas for consideration are identified below;

- *Land use change.* Some crops, particularly horticulture crops, will become unviable under current production systems and market prices. This could lead to change in land use, which may have economic and environmental impacts which could be positive or negative.
- *Food, feed and fuel supply chains.* Changes in UK production could affect a wide range of supply chains including the limitations on quantity and quality of horticulture produce, supply of wheat for milling, storage of potatoes for processing, and timing of supply, which may affect food prices and imports, investment and jobs.
- *Consumer behaviour*. The assumptions in this report, particularly for horticulture, are based on the assumption that consumer behaviour will continue to demand, perfect blemish free products. If these perfect blemish free products are not available, as a result of reduced pest or disease control, at an acceptable price will consumers change purchasing behaviour?
- *Waste*. The yield implications of reduced pesticide availability mean that there is the potential for a large increase in waste food and crop materials at the farm level. Some of the 'waste' will never be produced as crops with the potential for excessive yield lost just will not be grown. However, especially in fresh produce there is the potential that there will be an increase in the proportion of fruit and vegetable crops that are rejected due to failure to achieve quality specifications. Will there also be impacts on shelf life, especially where disease control has been impacted?
- *Jobs* – Reduced viability of certain crops and the subsequent business restructuring are likely to result in impacts on employment, especially if alternative crops are less labour intensive. Where production continues there is the potential for increased

labour requirements for hand weeding or grading of produce. The impacts on employment have not been quantified in this assessment.

SUPPORTING CROP LEVEL INFORMATION

Numbers in brackets following the active name indicate the impact of losing that active on the crop group or crop as specified. This impact is shown as a reduction in farmgate value in £M and also as a percentage reduction in farmgate value compared to the total value of the crop group or crop. Numbers are all rounded to the nearest £million, except for on lower value crops, and percentages are given to the nearest 1%, therefore as a result the percentages and numerical values my not be exactly the same, this is the rounding error.

Edible Horticulture

Alliums

The total farmgate value of the allium crop group (bulb onions, leeks and salad onions) is estimated at £116M per year (Table 15), with just over 12,000 ha of allium crops grown each year. Based on the expert summaries of the individual crops in this crop group it is estimated that a loss of the approved active substances in scenario 1 would cost the crop group £38M – 32% in reduced yield, with large losses in each of the crops, predominantly as a result of reduced disease control following the loss of **mancozeb** (£22M – 19%)**,** this would be particularly problematic in ***salad onions*** accounting for a £9M - 35% reduction in farmgate value.

In scenario 2 there would only be a modest reduction in farmgate value of the crop group, with total losses estimated at £40M – 34%. The unpredictable returns in scenarios 1 and 2, for what is a high investment crop would undoubtedly result in a significant reduction in UK area, restructuring and an increase in imports to meet UK demand.

In scenario 3 the yield cost to the allium crop group is estimated at £94M - or 81% of the value of the crop group. In effect the yield losses in this situation, with no effective disease control, serious challenges to weed control and little thrips control would result in allium crops becoming unviable to produce in the UK, without the introduction of new active substances or alternative control options. Growers could not risk growing such high input crops with no guaranteed return.

Table 15 Summary of economic losses £M - based on yield loss only, in allium crops across the three scenarios of endocrine disrupting pesticide loss

		Bulb onions	Leeks	Salad onion	All alliums
Crop area	**(ha)**	**8,859**	**1,759**	**1,672**	**12,290**
Production	**(t)**	**373,600**	**37,100**	**14,400**	**425,100**
Farmgate value	**(£M)**	**£60**	**£30**	**£26**	**£116**
Scenario 1	Fungicides	£12	£7	£10	**£29**
Scenario 1	Herbicides	£2	£3	£0	**£5**
Scenario 1	Insecticides	£0	£3	£0	**£3**
Scenario 1	All pesticides	£14	£13	£10	**£38**
Scenario 2	Fungicides	£12	£9	£10	**£31**
Scenario 2	Herbicides	£2	£3	£0	**£5**
Scenario 2	Insecticides	£0	£3	£0	**£3**
Scenario 2	All pesticides	£14	£15	£10	**£40**
Scenario 3	Fungicides	£17	£14	£14	**£45**
Scenario 3	Herbicides	£15	£9	£7	**£31**
Scenario 3	Insecticides	£4	£12	£3	**£18**
Scenario 3	PGR	£0	£0	£0	**£0**
Scenario 3	All pesticides	£35	£30	£24	£90

Scenario 1 – Mancozeb, tebuconazole, linuron, ioxynil (withdrawn 2017), abamectin, thiacloprid

The overall impact of the lost active substances in scenario 1 to the allium crop group is £38M - or 32% of the value of the crop group.

Mancozeb is a crucial part of the disease management strategy in alliums, especially for the control of downy mildew in bulb onions (£22M – 19%). Its loss not only removes a highly effective active substance, but also reduces the fungicide options available for use in resistance management strategies, increasing the likelihood of resistance developing to the remaining fungicides.

Scenario 2 – Above plus difenoconazole

The overall impact of the lost active substances in scenario 2 to the allium crop group is £40M - or 34% of the value of the crop group. The loss on **difenoconazole** would reduce disease control in leeks, reducing the value of the allium crop group by a further £2M – 2%.

Scenario 3 – Above plus chlorothalonil, prothioconazole, thiram, chlorpropham, dimethenamid-P, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad

The overall impact of the lost active substances in scenario 3 to the allium crop group is £90M - 77% of the value of the crop group.

The additional loss of fungicides in scenario 3 would reduce disease control further, reducing the value of the crop group by £45M - £17M or 28% reduction in farmgate value - ***bulb onions***, £14M - 45% reduction in farmgate value – ***leeks*** and £14M or 55% reduction in farmgate value - ***salad onions***) in lost yields, it will also prevent growers from being able to follow the FRAG guidelines for resistance management.

The combined loss of herbicides in scenario 3 is estimated to reduce the value of the ***allium*** crop group by £31M - £15M or 25% yield – ***bulb onions***, £9M or 30% yield – ***leeks*** and £7M or 27% yield -***salad onions***) in lost yield as a result of increased competition. The impact of the combined loss of insecticides is greatest on ***leeks***, where the physical damage caused by thrips in hot dry years could make the crop unmarketable (average yield impact estimated to be worth £12M – 40% in leeks).

In scenario 3 for ***leeks*** the loss of marketable yield would be complete, and in ***salad onions*** the marketable yield losses would also be nearly complete. In ***bulb onions*** there would be some marketable crop, but such a low proportion that it would be uneconomic to grow the crop. The combined loss of the fungicides, herbicides and insecticides in scenario 3 would result in complete loss of conventional allium production in the UK, in the absence of alternative controls becoming available.

Bulb Onions

There are approximately 8,860ha of bulb onions grown in the UK each year, with an estimated value of £60M at the farmgate.

Scenario 1 – Iprodione, mancozeb, tebuconazole, ioxynil (withdrawn 2017), linuron

The estimated impact of the loss of active substances in scenario 1 is £14M – 20%.

Loss of **mancozeb** would cause the single biggest economic loss (£11M – 18%) of any active ingredient to the UK bulb onion crop. Mancozeb is an important constituent of four of the most important products/generics used for control of downy mildew. Despite mancozeb being widely used for a number of years there is no known resistance to the active and loss would put extreme pressure on strobilurin based alternatives. The loss of mancozeb would make it impossible for UK growers to adhere to FRAG guidelines on strobilurin use. Average yield loss is estimated at 18% year on year, but would be expected to be significantly higher in some years giving a 'roller coaster' effect on total production causing extreme price volatility. A volatile price with uncertain returns for growers would likely see a significant drop in UK cropped area and an increasing reliance on both EU and southern hemisphere imports (currently the UK grows only 60% of consumption).

Tebuconazole is not a fungicide widely used for bulb onion production. Use is largely concentrated in areas where production has been established for a number of years. Although estimated yield loss is relatively low, tebuconazole is important in these established areas for control of white rot (*Sclerotium cepivorum*) a devastating soil borne disease. Loss of tebuconazole would result in around 6-800ha of land (circa 7%) currently used for growing bulb onions being taken out of production (£1.2M – 2%).

Approval for **ioxynil** has been revoked in the UK, taking effect from 31 August 2017. Ioxynil is the most widely used contact herbicide in bulb onions. As approval has already been revoked the potential impact of the loss of ioxynil has been excluded. However, the additional loss of **linuron** would result in losses of £2.4M – 4%.

Scenario 2 – Above plus propiconazole, deltamethrin

No additional impact.

Scenario 3 – Above plus prothioconazole, S-metolachlor, chlorpropham, dimethenamid-P, fluazifop-P-butyl, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad

The total losses to the bulb onion crop from Scenario 3 are estimated at £35M – 59%. The largest losses are as a result of reduced disease control (£17M – 28%), and reduced weed control (£15M – 25%) with more modest losses as a result of reduced pest control (£4M – 6%).

Dimethenamid-P, is currently used on every bulb onion crop in the UK in mixtures with pendimethalin, as Wing P, this would be the most significant herbicide loss. Without dimethenamid-P extremely competitive weeds such as groundsel and annual meadow grass would cause significant yield loss (both in the field and store), losses estimated at £4M – 6%.

Loss of **chlorpropham** would make it uneconomic to grow the 1100ha of bulb onions currently produced on peat soils as it is the only residual herbicide that it effective on soils with a high organic matter (amounting to losses of £3M – 5%). Loss of this area would put additional pressure on other production areas potentially resulting in a 'shortening' of rotations.

Tepraloxydim is the most widely used graminicide for control of annual meadow grass in the UK with over two thirds of the area being treated annually. As well as being extremely competitive, severe annual meadow grass infestations can make it impossible to harvest the crop and drying/storage can be compromised, losses estimated at £6M – 10%.

Chlorpyrifos and **spinosad** are the only two effective insecticides currently approved for control of Thrips. Whilst Thrips are not problematic every year, in hot, dry summers yield

losses in excess of 15% can occur. These losses are a combination of both foliage damage as well as damage to bulbs in store, £2M – 3% for each active.

Conclusion

Loss of **mancozeb** in Scenario 1 would make onion production in the UK unpredictable as crops succumb to downy mildew in high disease pressure years. Unpredictable returns for what is a high investment crop would undoubtedly result in a significant reduction in UK area and an increase in imports. Additional loss of tebuconazole in Scenario 1 would cause limited economic loss for the crop, but as land suitable for onion production is limited would put additional pressure on other production areas to shorten rotations raising questions on long-term sustainability.

Scenario 3, where mancozeb, along with three of the most important residual herbicide active substances chlorpropham, tepraloxydim and dimethenamid-P and the only two effective insecticides for control of *Thrips tabaci*, chlorpyrifos and spinosad were lost this would reduce overall yields annually by an estimated 59%. This level of loss would be devastating for the UK bulb onion crop, and with farmgate values unlikely to more than double to compensate growers, this would result in a significant reduction in area grown, loss of jobs in the crop and an increased reliance on EC and extra-EC imports.

Industry Comment: *"British Onions strongly supports the estimates of economic loss in this report. The pesticide armoury available to horticulture has declined significantly in recent years and further losses due to proposed ED regulations will only result in increased food prices, job losses and additional extra-EU imports." Chris Wilkinson, Chairman British Onions* ***(www.britishonions.co.uk).***

Leeks

There are approximately 1,760 ha of leeks grown in the UK, with an estimated farmgate value of £30M.

Scenario 1 – Mancozeb, tebuconazole, ioxynil (withdrawn 2017), linuron, abamectin, thiacloprid

The loss of active substances in scenario 1 is estimated to reduce the value of the leek crop by £13M – 42% in lost yield, making leek production in the UK unviable for most growers. The main loss is as a result of reduced disease control £7M – 22%, with additional yield loss as a result of herbicides (£3M – 10%) and insecticides (£3M – 10%).

The loss of **tebuconazole** for rust control would be an important loss for the crop as this has been a mainstay of control for many years. Whilst there are other active substances

approved including other triazoles it is important to have a range of active substances for resistance and residues management (£4.5M – 15%).

A high proportion of leeks are grown on organic soils and with a long growing season they are subject to repeated weed flushes, with the impending loss of **ioxynil** (2017) it therefore becomes crucial to have a full herbicide armoury including **linuron** (£3.0M - 10%).

The losses of **abamectin** (£1.5M - 5%) and **thiacloprid** (£1.5M - 5%) would halve the armoury for effective thrips control, in hot dry years when thrips are more active it simply would not be possible under current approvals to apply a sufficient number of insecticides to fully control thrips leading to serious economic losses.

Scenario 2 – Above plus difenoconazole, deltamethrin

A similar result to scenario 1, but with the added impact of the loss of **difenoconazole** (£2.3M – 7%), another active which offers very good levels of control of leek rust. Total losses from this scenario are estimated to rise to £15M – 50%.

Scenario 3 – Above plus prothioconazole, thiram, chlorpropham, dimethenamid-P, fluazifop-p-butyl, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad

The loss of active substances in scenario 3 is expected to result in a complete loss of the UK leek crop, with growers not being able to control disease (£14M – 45%), pests (£12M – 40% or weeds (£9M – 30%).

The combined losses of **difenoconazole**, **mancozeb**, **prothioconazole** (£3.0M 0 10%), **tebuconazole** and **thiram** (£1.5M – 5%) would mean the only significant fungicides left would be strobilurins. Levels of disease control would be significantly reduced and resistance guidelines produced by FRAG could not be met. Following continued and repetitive use of only strobilurins there would undoubtedly be widespread resistance and a complete breakdown in rust and white tip control.

The combined losses of **chlorpropham -** £1.5M – 5%)**, dimethenamid-P** (£1.5M – 5%)**, ioxynil, linuron** and **tepraloxydim** (£3.0M – 10%) would make commercial leek production unsustainable in the UK as it currently stands. With an increase in row width and use of inter-row cultivation some reduction in the probable amount of hand labour needed for weeding could be achieved, but there would be a substantial yield loss and increase in costs.

The combined losses of **chlorpyrifos** (£3.0M – 10%)**, lambda-cyhalothrin** (£3.0M – 10%)**, spinosad** (£3.0M – 10%) and **thiacloprid** (£3.0M – 10%) would mean there would be no measures at all for the control of thrips or cutworms. In hot dry summers this could lead to complete crop loss.

Conclusion

Scenario 1 This would cause a significant - £13M – 42% loss to UK leek growers, by increasing losses from leek rust, weed competition and increased thrips damage. At this level of losses many growers would no longer be profitable and would go out of production, further increasing the losses.

Scenario 2 - This scenario would include the loss of difenoconazole which makes a very effective and important contribution to rust control and would increase the farmgate loss to £15M - 50%.

Scenario 3 - With the losses of these combined active substances it would be difficult to see any future at all for UK leek production. There would be no effective thrips or cutworm control, rust control would be minimal and overall disease control would deteriorate due to over reliance on strobilurins. Total economic losses at £30M – 100%, potentially writing off the total UK crop output. Consequential job losses would be in the order of 1000.

Salad Onion

There are approximately 1,670 ha of salad onions grown each year in the UK, with an estimated farmgate value of £26M.

Scenario 1 – Mancozeb, tebuconazole, ioxynil (withdrawn from 2017)

The loss of active substances in scenario 1 is estimated to result in a £10M – 40% reduction in farmgate value of the crop as a result of a reduced ability to control disease.

The extremely limited number of fungicide approvals for salad onions mean the loss of **mancozeb** would cause the single biggest economic loss of any active ingredient (£9M – 35%). Mancozeb is an important constituent of the two most important fungicide products used on the crop. Despite mancozeb being widely used for a number of years there is no known resistance to the active and loss would put extreme pressure on the one remaining straight SL567a (metalaxyl-m) which needs to be mixed with a strobilurin fungicide for resistance management (which would still give inadequate control and reliability). Average yield loss is estimated at 35% year on year, but would be expected to be significantly higher for some sowings throughout the year, with spring/autumn production likely to be uneconomic in most years.

Tebuconazole is not a fungicide routinely used for salad onion production and use is largely concentrated in areas where production has been established for a number of years. Although estimated yield loss is relatively low (the tolerance for white rot in a field is low to avoid quality problems) tebuconazole is important in these established areas for control of

this devastating soil borne disease. Loss of tebuconazole would result in around 2-300ha of land currently used for growing salad onions being taken out of production (£1.3M – 5%).

Scenario 2 – Above plus deltamethrin

No additional impact.

Scenario 3 – Above plus chlorothalonil, thiram, chlorpropham, dimethenamid-P, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad

The additional loss of active substances in scenario 3 is expected to result in yield losses of £24M – 92%, effectively resulting in the complete loss of salad onion production in the UK. The main losses are as a result of reduced disease control (£14M- 55%), but reduced weed control (£7M – 27%) and reduced pest control (£3M – 10%) would make a difficult situation even more challenging.

Whilst loss of broad-leaved contact herbicides such as ioxynil would make weed control difficult, loss of residual herbicides such as **chlorpropham -** £2.6M – 10%), **dimethenamid-P** (£3.1M – 12%) and the graminicide **tepraloxydim** (£6.6M – 9%), would be significantly more worrying. Salad onions are extremely uncompetitive and the multiple, narrow rows typically used (to maximise yield and give uniformity of size) are less suitable for inter-row mechanical weed control. The combined loss of these three herbicides would give a total estimated yield loss of £7M - 27%. The additional loss of **ioxynil** needs to be taken into account as at present there is no suitable approved alternative. The combined effect of the loss of all four active substances above is likely to result in further major yield reductions.

Dimethenamid-P, currently used on every salad onion crop in the UK in mixtures with pendimethalin, as Wing P, would be the most significant residual herbicide loss. Without dimethenamid-P extremely competitive weeds such as groundsel and annual meadow grass would cause significant yield loss (both during growth and harvest).

Loss of **chlorpropham** would make control of small nettle, polygonums and brassica weeds difficult. Small nettle is a problematic weed on lighter soil types, where salad onions are predominantly grown, and brassica weeds (including oilseed rape) are widespread causing significant yield loss via competition, as well as increasing hand harvesting costs.

Tepraloxydim is the most widely used graminicide for control of annual meadow grass in the UK with over two thirds of the area being treated annually. As well as being extremely competitive, severe annual meadow grass infestations can make it difficult to harvest the crop.

Chlorpyrifos (£5.6M – 3%) and **spinosad** (£6.6M – 7%) are the only two effective insecticides currently approved for control of *Thrips tabaci*. Whilst Thrips are not

problematic every year, in hot, dry summers yield losses in excess of 30% can occur. These losses are due to silvering on the foliage making the onions unmarketable and is a quality issue rather than a direct effect on yield.

Conclusion

Each of the three possible scenarios present their own issues: loss of mancozeb in Scenario 1 would make salad onion production in the UK exceptionally unpredictable. Unpredictable returns for what is a high investment crop would undoubtedly result in a significant reduction in UK area, restructuring and an increase in imports. Additional loss of tebuconazole in Scenario 1 would cause limited economic loss for the crop, but as land suitable for salad onion production is limited would put additional pressure on other production areas to shorten rotations raising questions on long-term sustainability.

Scenario 3, where mancozeb, along with three of the most important residual and contact herbicide active substances (chlorpropham, tepraloxydim and dimethenamid-P) and the only two effective insecticides for control of *Thrips tabaci*, chlorpyrifos and spinosad were lost could combine to reduce overall yields annually by up to an estimated 92%. This level of loss would be devastating for the UK salad onion crop and would result in salad onions no longer being widely grown in the UK, leading to an increased reliance on extra-EC imports.

Industry Comment: *"The loss of active ingredients described, particularly mancozeb, would be 'business critical' in deciding whether salad onion production remains viable in the UK. Alternative products or methods of control MUST be found before withdrawal of these active substances takes place."* **Phil Langley, Agronomist, Sandfields Farms Ltd.**

Field Vegetables

The total farmgate value of the field vegetable crop group (asparagus, beetroot, brassica, carrot, courgette and sweetcorn) is estimated at £511M per year (Table 16), with just under 50,000 ha of field vegetable crops grown each year. The largest crop in terms of area grown and value is the brassica crop at £279M per year, with the carrot crop accounting for a further £126M.

Table 16 Summary of economic losses £M - based on yield loss only, in field vegetable crops across the three scenarios of endocrine disrupting pesticide loss

		Asparagus	Beetroot	Brassicas	Carrot	Courgette and cucurbits	Sweetcorn	Field Vegetables
Crop area	**(ha)**	**1,990**	**1,677**	**31,221**	**10,859**	**30**	**2,000**	**47,777**
Production	**(t)**	**5,400**	**62,300**	**510,900**	**663,700**	**52,500**	**11,850**	**1,306,650**
Farmgate value	**(£M)**	**£29**	**£27**	**£279**	**£126**	**£40**	**£10**	**£511**
Scenario 1	Fungicides	£0	£5	£20	£6	£6	£0	**£37**
Scenario 1	Herbicides	£2	£0	£0	£33	£0	£0	**£35**
Scenario 1	Insecticides	£7	£4	£42	£6	£6	£0	**£65**
Scenario 1	All pesticides	£10	£9	£61	£45	£12	£0	**£137**
Scenario 2	Fungicides	£1	£5	£33	£11	£12	£0	**£63**
Scenario 2	Herbicides	£6	£3	£0	£58	£2	£0	**£69**
Scenario 2	Insecticides	£7	£4	£50	£14	£6	£0	**£81**
Scenario 2	All pesticides	£14	£12	£84	£83	£20	£0	**£213**
Scenario 3	Fungicides	£3	£21	£81	£19	£12	£0	**£136**
Scenario 3	Herbicides	£7	£13	£11	£61	£3	£3	**£97**
Scenario 3	Insecticides	£9	£7	£123	£23	£6	£0	**£167**
Scenario 3	PGR	£0	£0	£0	£0	£0	£0	**£0**
Scenario 3	All pesticides	£19	£27	£215	£102	£21	£3	£386

Scenario 1 – Cyproconazole, iprodione, myclobutanil, tebuconazole, linuron, cypermethrin, thiacloprid

The overall impact of losing the active substances in scenario 1 on yield to the field vegetable sector is £137M - 27% of the value of the crop group. The loss of **thiacloprid** is expected to cause the largest impact in this scenario accounting for a £57M - 11% reduction in farmgate value of the crop. The main crops impacted are ***brassicas*** (£42M – 15%) and ***courgettes and cucurbits*** (£6M -15%), closely followed by ***asparagus*** (£3M - 10%). The loss of **linuron** (£35M – 7%) would cause serious challenges to weed control and subsequent loss of value in ***carrots*** (£33M - 26%) and ***asparagus*** (£2.3M - 8%). The loss of **tebuconazole** would reduce the value of the crop group by £20M - 4%, predominantly affecting disease control in carrot and brassica. Although relatively minor at the crop group level the loss of **cyproconazole** (£5M – 1%) would result in a £5M - 18% reduction in the value of the beetroot crop, whilst the loss of **myclobutanil** would reduce the value of the courgette crop by £6M -15%. No products approved for use in sweetcorn are affected by this scenario.

Scenario 2 – Above plus bupirimate, difenoconazole, metribuzin, triflusulfuron methyl, deltamethrin

The overall impact of lost yield in scenario 2 for the field vegetable crop group is £213M - or 42% of the value of the crop group. The main impacts in this scenario are from a further loss of weed control in carrots (20%) and asparagus (12%) as a result of the loss of **metribuzin**. In carrots the combined loss of linuron and metribuzin would make weed control almost impossible, leading to significant yield losses and many growers going out of business, especially when combined with additional yield losses from reduced disease (9%) and pest (11%) control, bringing the combined loss of value to 66%, or 83M. The loss of **bupirimate** in courgette would have a significant impact on powdery mildew control in courgette, reducing the value of the crop by 15%. No products approved for use in sweet corn are affected by this scenario.

Scenario 3 – Above plus cymoxanil, fosetyl aluminium, prothioconazole, thiram, ethofumesate, fluazifop-P-butyl, S-metolachlor, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat

The overall impact to the crop group in scenario 3 is at least £386M – 76%. At this level of loss, it is expected that the majority of field vegetable growers would go out of production. Individual crop losses range from £2.9M - 29%) in sweetcorn, through to complete loss of value in beetroot, with brassicas reducing in value by £214M - 77%) and carrots by £102M - 81%). The loss of insect pest control would cause the largest reduction in farmgate value (£167M - 32%), brassicas being worst affected (£123M - 44%). However, reduced disease control, especially pythium control in beetroot (**cymoxanil** and **thiram**), will also reduce the value of the crop group by £136M - 27%). The combined reduction in farmgate value to reduced weed control is £97M - 19%).

In reality in this scenario the risk associated with the production of these crops would mean that the majority of vegetable growers would cease production, with knock on impacts on seasonal labour for picking and packing. Vegetable production tends to be focused in particular regions of the UK, where soil and environmental conditions are suitable, e.g. Norfolk, Nottingham - carrots), Lincolnshire, Cornwall and Fife (brassicas), therefore job losses will have a high impact at a local level. Given that multiple crops will be affected, especially in the worst case scenario 3, there will be few alternative jobs for these workers to move in to. Many of these vegetable growing regions have few alternative job opportunities outside of agriculture, meaning that the wider impacts on the local communities will extend beyond the immediate job losses at the farm level – however these impacts are outside of the scope of this report to assess.

Asparagus

There are approximately 1,990 ha of asparagus grown in the UK, with an estimated farmgate value of £30M.

Scenario 1 – Linuron, cypermethrin, thiacloprid

The estimated impact of the loss of active substances in scenario 1 is estimated to be a £10M – 33% reduction in farmgate value.

Linuron is the backbone for a majority of growers post season weed control strategy. There are other chemicals, which could be used to provide a level of control, but losses would still accumulate from late germinating weeds, e.g. black nightshade. It is estimated the reduction in value would be in the region of £2.3M - 8%.

The loss of both **cypermethrin** (£4.3M - 15%) and **thiacloprid** (£2.9M – 10%) would only leave spinosad for pest control. Untreated asparagus beetle populations in fern will significantly reduce the carbohydrate produced to fuel the next crop as well as leaving a large population to affect the production in season. Without control of asparagus beetle it is estimated that 15% of spears would be directly rendered un-marketable through pest contamination or damage. During the fern period the damage to the fern will reduce photosynthetic area and cause plant stress, both of which will reduce potential yield for the following year, estimated to also be in the region of 10% loss of yield.

Scenario 2 – Above plus difenoconazole, metribuzin

The estimated impact of the loss of active substances in scenario 2 is estimated to be a £14M – 50% reduction in farmgate value.

Difenoconazole (£1.4M – 5%) is the only partially curative fungicide available for stemphylium control. It is used on the majority of asparagus crops and has been proven in trials to be one of the most effective products. Difenoconazole is the only active available from the triazole group and its loss would increase the reliance on strobilurins. The loss of this active would lead to an increased level of disease in fern and carry over into the following crop.

The loss of **metribuzin** would mean a significant reduction in weed control. This would lead to plant stand loss and reduced carbohydrate to fuel production the following year. Conservative estimates indicate a £3.5M - 12% reduction in value.

Scenario 3 – Above plus chlorothalonil, fluazifop-p-butyl, glufosinate ammonium, spinosad

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £19M – 65% reduction in farmgate value.

Chlorothalonil is used as a fungicide for stemphylium control in the fern phase of asparagus growth. In trial this product has been shown to be the most effective treatment. Alternatives are available, but if chlorothalonil was lost in combination with difenoconazole the crop group would become heavily reliant on strobilurins. Growers would not be able to adhere to FRAG guidance. Reduced value estimated at £2M - 7%.

Fluazifop-p-butyl is used in fields where grass weeds are a known problem and critical in the control of Couch grass (*Elymus repens*). Total reduction in farmgate value for the UK is estimated at £0.8M - 3%.

Spinosad (£1.4M – 5%) is used as a third line beetle control and primary thrips control product. Losing it alongside cypermethrin and thiacloprid would leave no targeted thrips or beetle control products. As a general insecticide pyrethrins would still be available, but efficacy has not been proven for control of asparagus beetle and there would be considerable resistance issues in its sole use.

Conclusion

The majority of the active substances outlined are critical parts of the control strategy in each area. As a niche horticultural crop, asparagus already works with a limited range of active substances and reduced availability of active substances as a result of defining endocrine disruptors could cause significant shifts in the levels of control growers can achieve and the resultant economics and viability of production.

As a perennial crop, asparagus can accumulate problems, which then reduce yield in subsequent seasons. Its perennial nature also means that rotation cannot be employed on a short timescale to rid fields of accumulated issues. During the fern phase the root system is recharged with carbohydrate, which fuels the following season's harvest. Any reduction in photosynthesis through premature defoliation, loss of resources by competition with weeds or grazing by insects, then goes on to impact on the yield in the following year. This creates a vicious cycle of decline where each season the harvest reduces the root carbohydrate causing the fern to establish poorly so puts less back into the roots. Within a couple of seasons this causes plant loss and renders the field unviable.

Overall the largest commercial impact would be seen in scenario 2, although scenario 1 already reduces yields by such a considerable margin that the viability of the crop becomes questionable. In scenario 2 the main proven control of asparagus beetle, the two main herbicides and the main fungicide would all be lost. Without significant introductions of new products to replace these losses there will be either be a significant price increase needed or a major reduction in the UK asparagus cropping area.

Scenario 3 would also leave the crop without any proven asparagus beetle or thrips control products and totally reliant on pyrethrin for any insect control.

British asparagus is a hand harvested premium seasonal vegetable. Consumer demand for the crop has grown considerably in the last 15 years and has been exceeding plantings. The British asparagus area has been expanding to meet the demand and replace the need for imported material. Asparagus is produced year round in Peru and Mexico and is seasonally available from Italy and Spain. Even with the air freight costs, Mexican and Peruvian asparagus is cheaper than the British product. In part this is due to the reduced labour costs in these countries and in part due to the increased crop yield achieved in these climates.

Asparagus is generally seen as a luxury and the market would not be able to absorb the sort of increased costs associated with the yield losses outlined in these scenarios. The natural result would be for multiple retailers to restrict the British product to top stores and switch the volume sales to a cheaper imported offer. At present the British crop employs approximately 1990 seasonal staff in harvesting alone. In the absence of the active substances outlined in these scenarios there would be a significant reduction in crop area, restructuring of businesses and loss of associated jobs.

Beetroot

There are approximately 1,680 ha of beetroot grown in the UK, with an estimated farmgate value of £27M.

Scenario 1 – Iprodione, cyproconazole, thiacloprid, cypermethrin

The estimated impact of the loss of active substances in scenario 1 is estimated to be a £9M – 33% reduction in farmgate value.

The most serious loss under scenario 1 would be **cyproconazole**, as it controls a wide range of diseases, which if left uncontrolled will result in secondary infections occurring during storage and impacting on final yield with an estimated reduction in farmgate value of £5M - 18%. The loss would result in the increased use of the strobilurins and the possible development of resistance issues.

The loss of **thiacloprid** (£1.4M - 5%) and **cypermethrin** (£2.7M – 10%) would make aphid and caterpillar control very difficult, as very few approved control options would remain.

Scenario 2 – Above plus triflusulfuron-methyl

The estimated impact of the loss of active substances in scenario 2 is estimated to be a £12M – 43% reduction in farmgate value.

Triflusulfuron – methyl is used extensively within the crop for the control of a wide spectrum of broadleaf weeds. It is an ideal tank mix and can be applied at an early stage of growth without any detrimental effect on the young seedlings. Its loss would make weed control very challenging, resulting in potential issues at harvest (estimated reduction in farmgate value £2.7M - 10%).

Scenario 3 – Above plus cymoxanil, thiram, ethofumesate, fluazifop-p-butyl, lenacil, S-metolachlor, tepraloxydim, lambda-cyhalothrin

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £27M – 100% reduction in farmgate value.

The combined losses under scenario 3 would mean that growing beetroot in the UK (currently grown in Cambridgeshire, Norfolk, Lancashire and Lincolnshire) would become unachievable. Disease control will be very challenging in scenario 1 with the loss of **cyproconazole**. The additional loss of the two key fungicides (**cymoxanil** £8M – 30% and **thiram** £8M – 30%) which are present in seed treatments and are used extensively in the UK for the control of pythium, phoma and root malformation disorder (RMD), will result in the crop being very reliant on metalaxyl-m, which could potentially result in the development of resistance issues and RMD will become a major issue for the crop, again with potentially very high yield losses.

Weed control of both grass weeds and broad leaf weeds will become extremely challenging on all soil types if **ethofumesate** (£3M – 10%)**, fluazifop-P-butyl** (£3M – 10%)**, lenacil** (£1M - 3%)**, S-metolachlor** (£1M – 3%) **, tepraloxydim** (£3M – 10%) and **triflusulfuron-methyl** (£3M – 10%) were to be lost, this would have a serious impact on yield and we would be left with very few approved active substances. **Tepraloxydim** is widely used for the control of grass weeds, being particularly effective on annual meadow grass. The loss of **ethofumesate** would have a significant impact on the viability of growing beetroot on organic soils, as it is very effective at controlling a wide spectrum of weed species at low dose rates.

With the loss of the three insecticides, aphid and caterpillar control will be challenging with the limited range of approved products which would remain. **Thiacloprid** (£1M – 5%) lost in scenario 1, is very effective on aphids, and its loss will make control very difficult and increases the risk of virus spread by aphids. The loss of both pyrethroids– **lambda-cyhalothrin** (£3M – 10%) and **cypermethrin** (£3M – 10% lost in scenario 1) will make silver y caterpillar control very challenging, particularly in hot summers. If uncontrolled they will cause extensive foliage damage, affecting the development of the bulbs and resulting in potential yield loss.

Conclusion

Scenario 1 would result in £9M reduction in farmgate value of the crop, due to the reduced disease control with the loss of **cyproconazole** and aphid control would be very challenging with the loss of **thiacloprid** particularly in a high aphid pressure season.

The additional loss of **triflusulfuron-methyl** under scenario 2, would make weed control very challenging and the loss to the crop would increase to £12M.

The loss of key active substances for weed (**ethofumesate, fluazifop-P-butyl, lenacil, tepraloxydim, triflusulfuron-methyl**), pest (**thiacloprid, cypermethrin, lambda-cyhalothrin**) and disease (**cyproconazole, thiram, cymoxanil**) control under scenario 3 would result in the growing of beetroot becoming unsustainable in the UK with the economic loss being greater than the farmgate value. This would be devastating for the beetroot crop in the UK, leading to imports from within the EU and outside the EU resulting in significant job losses.

Brassicas

There are approximately 31,220 ha of brassicas grown in the UK, with an estimated farmgate value of £279M.

Scenario 1 – Iprodione, mancozeb, tebuconazole, thiacloprid, cypermethrin

The estimated impact of the loss of active substances in scenario 1 is estimated to be a £61M – 22% reduction in farmgate value.

Of the four triazoles (**tebuconazole, fluasilazole, difenoconazole** and **prothioconazole**) approved on brassica crops, **tebuconazole** (£14M – 5%) is the most widely used, as it gives relatively broad spectrum disease control, there would be increased costs associated with replacing tebuconazole with more expensive alternatives.

Loss of **thiacloprid** (£42M – 15%) would cause significant economic loss to the UK brassica crop and make it impossible to control aphids through the autumn and into the winter. Thiacloprid is important for control of late season aphids as it provides more effective control at lower temperatures than alternative aphicides such as pirimicarb, pymetrozine, and spirotetramat.

Scenario 2 – above plus difenoconazole, carbetamide, propyzamide, deltamethrin

The estimated impact of the loss of active substances in scenario 2 is estimated to be an £84M – 30% reduction in farmgate value.

Loss of the two most widely used triazoles, **difenoconazole** (£14M – 5%) and **tebuconazole**, would leave the brassica crop with just two remaining active substances in

this group. Fluasilazole approvals expired in October 2014, therefore only prothioconazole would remain from 2015. With only 3 applications of prothioconazole permitted this would leave long season crops such as sprouts and cabbage at significant disease risk.

Scenario 3 – Above plus chlorothalonil, fosetyl aluminium, prothioconazole, thiram, dimethenamid-P, fluazifop-p-butyl, S-metolachlor, tepraloxydim, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £215M – 77% reduction in farmgate value.

Complete loss of the triazole group of fungicides would lead to average annual losses in excess of 20%. With no currently approved alternatives for control of the various leaf spots, autumn/winter production of brassica crops would be severely affected leading to unpredictable supply/price.

Loss of **S-metolachlor** (£8M – 3%) and **tepraloxydim** (£3M – 1%) would currently have relatively little impact on brassica weed control, with alternatives such as pendimethalin, metazachlor and clomazone not considered to be endocrine disruptors. However, there are question marks over the continuing approval of pendimethalin and with limits on the use of metazachlor and clomazone, use of S-metolachlor may become more important in the future.

Loss of the insecticide **spinosad** (£45M – 16%) would be the most significant loss in Scenario 3. Cabbage root fly is a significant pest of brassica crops and with almost 90% of the crop planted as transplants the spinosad drench would be the only approval for control once the chlorpyrifos drench approval expires. Whilst losses of 40% can occur in periods of peak egg-laying activity, the 3 overlapping generations of cabbage root fly mean that risk is continuous from early May through to the end of October.

Conclusion

Scenario 1 – Loss of the insecticide **thiacloprid** and the most widely used triazole, **tebuconazole** would give a combined average annual reduction in farmgate value of 20% or £56M. At particular risk would be autumn/winter crops, the peak period for brassica production and consumption. This level of loss would make it uneconomic to grow long season brassica crops, such as autumn/winter cabbage and Brussels sprouts in the UK, with the inevitable reduction in area, loss of jobs and increased reliance on EU and extra EU imports.

Scenario 2 – the revocation of a second triazole (**difenoconazole**) would put additional pressure on autumn/winter disease control.

Scenario 3 – Triazoles make up the 'backbone' of disease control in brassica crops, giving effective control of a wide range of foliar diseases. With all three currently approved triazoles listed as Endocrine disruptors or potential Endocrine disruptors, effective disease control would be impossible even in relatively low disease years. Loss of this important group of fungicides would give a combined total loss of £59M – 21%.

Loss of the 5 insecticide active substances (**thiacloprid, chlorpyrifos, spinosad, lambda-cyhalothrin** and **spirotetramat**) would give an annual loss of £114M – 41%. The combined average annual reduction in farmgate value of the brassica crop as a result of losses in Scenario 3 is estimated at £215M – 77% at farmgate level. Impacts of this magnitude would mean that virtually all horticultural brassica production in the UK would cease unless farmgate prices were significantly increased to compensate.

Many of the active substances in scenarios 1 to 3 enable the cost-effective production of high quality produce and loss of these active substances will inevitably result in lower yields, more variable quality and higher levels of wastage. All three scenarios will result in significantly increased prices on the supermarket shelves with the inevitable effect on consumption.

The brassica crop relies heavily on manual labour for most planting, harvesting and packing operations and is a major employer in several rural areas of the UK i.e. Lincolnshire, Cornwall, Lancashire, and Fife. These jobs are at significant risk from all three scenarios.

Industry Comment: *"*The Brassica Growers Association strongly supports the estimates of economic loss contained in this report. The profitability of brassica growing in the UK is currently on a 'knife-edge' and loss of key active substances due to proposed new ED regulations would result in a significant drop in area grown, reduced farm-gate income, inevitable job losses, increased imports and higher prices on the supermarket shelves"

Carrot

There are approximately 10,860 ha of carrots grown in the UK, with an estimated farmgate value of £126M.

Scenario 1 – Iprodione, mancozeb, tebuconazole, linuron, thiacloprid, cypermethrin

The estimated impact of the loss of active substances in scenario 1 is estimated to be a £45M – 36% reduction in farmgate value.

Loss of **tebuconazole** (£6M – 5%) would have a significant impact on disease control as it constitutes around 30% of fungicide programmes as a straight product or in mixture with

trifloxystrobin. In high risk years this would make crops more susceptible to yield suppressing diseases such as alternaria.

The loss of **linuron** would be the single biggest economic impact of any active ingredient to the UK carrot crop. Linuron has broad-spectrum activity for pre-emergence weed control and has no replacement. Post-emergence, alone or in mixture, it is relied on very heavily to control a wide range of weeds in carrots. It is the only active in mixture, which will control volunteer potatoes in carrot, one of the most yield suppressing weeds. Average reduction in farmgate value in the absence of linuron is estimated at £33M -25%, but in fields with a high levels of weeds it would be significantly higher. With this level of yield suppression growers would likely see a significant reduction in output and increase reliance on imports from the EC and other countries.

Scenario 2 – Above plus difenoconazole, metribuzin, deltamethrin

The estimated impact of the loss of active substances in scenario 2 is estimated to be a £83M – 66% reduction in farmgate value.

The loss of a second key fungicide, **difenoconazole** (£5M – 4%) in scenario 2, would be a serious blow to disease control and would deplete the effective fungicide armoury by 50% to protect against damaging disease such as alternaria and sclerotinia.

The combined loss of **linuron** and **metribuzin** (£25M – 20%) would effectively rule out any post-emergence chemical control of broad leaved weeds. Linuron and metribuzin complement each other very well, each being strong on the others weaknesses. Without metribuzin there are no products post-emergence for mayweed control. The loss of both these active substances would bring post-emergence weed control in carrots close to organic production systems, where yield expectations are half that of conventional crops. Estimated loss of both these active substances will therefore lead to a reduction in farmgate value of £58m - 45%, in the absence of organic premiums these yield losses would be unsustainable in the conventional carrot crop.

Carrots require protection over several months from 2 to 3 generations of carrot fly which cause damage to roots and from carrot willow aphid to prevent transmission of viruses which reduce yield and root quality. The number of approved insecticides to control these pests is limited, there are effective alternatives available for the control of carrot fly, al be it at higher cost however, and aphid control would be compromised. To lose two of the main products **deltamethrin** (£8M – 6%) and **thiacloprid** would severely compromise control and would lead to an estimated combined loss of marketable yield of 11%.

Scenario 3 – Above plus cymoxanil, prothioconazole, fluazifop-p-butyl, tepraloxydim, lambda-cyhalothrin

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £102M – 81% reduction in farmgate value.

The loss of **prothioconazole** in this scenario would further deplete the fungicides available for control of alternaria and sclerotinia in particular. The estimated impact would be a £5M – 6% reduction in farmgate value.

Lambda- cyhalothrin (£9M – 7%) provides the most effective control of carrot fly. Along with **deltamethrin** these products form the backbone of carrot fly control programmes and give protection against aphids at the same time. Control of aphids and carrot fly may be needed for five months during the growing season. With the combined loss of the insecticides in scenario 3, there would be few effective alternatives for aphid control, although carrot fly could be controlled at extra cost using chlorantraniliprole off label, resulting in estimated reduction in farmgate value of 18%.

Conclusion

The loss of **linuron** in Scenario 1 would make maintaining the current level of carrot production in the UK very difficult. Not only will yields be significantly reduced, but cost of production would increase dramatically with extra investment required in new mechanical machinery and intensive hand weeding. Add Scenario 2 to this with the loss of **metribuzin** and production would be potentially cut in half. The loss of key insecticides and fungicides in scenario's 1, 2 and 3 would undoubtedly have a serious impact on crop quality and a further significant depression of yield. The combined loss of active ingredients from all the scenarios could result in an overall reduction in farmgate value as high as 80%.

Overall the impact of each of these Scenarios would lead to increased imports from EU and other countries and during the spring could result in crop shortages before new crop was ready to be imported. Carrots are a staple food in the UK and are a key element in a government led drive to improve public health, thus carrot shortages would have a negative impact on this initiative. With higher growing costs and lower production, farmgate values are unlikely to more than double to compensate growers. Under such pressure the UK carrot packing and processing industry would find it difficult to maintain their current structures. It will almost certainly mean the loss of UK jobs and may result in some carrot growers and companies going out of business.

Industry Comment: *"The loss of these chemicals would have a serious impact on my carrot business. I can't sell small carrots - with tonnage down significantly and cost ups, my customers are unlikely to pay me more for less. If there was no profit we would have to move away from growing carrots and cut back on labour"*. **Guy Poskitt,** a Yorkshire farmer, Guy grows over 600 ha of carrots and parsnips and he runs a packhouse employing over 200 staff. He is the current NFU Chairman for

Courgette and cucurbits

There are approximately 1,400 ha of courgette and cucurbits grown in the UK, with an estimated farmgate value of £40M.

Scenario 1 – Myclobutanil, thiacloprid

The estimated impact of the loss of active substances in scenario 1 is estimated to be a £12M – 36% reduction in farmgate value.

Myclobutanil is used within the courgette crop for control of powdery mildew a major disease within the cucurbit category. The importance with the control of any fungal disorder is to have a resistance strategy identified. Left alone the yield losses to powdery mildew can be a 30% reduction in yield, £6M - 15% to just myclobutanil loss

Thiacloprid (£6M – 15%) is one of a small range of aphicides essential for the control of aphid vectored virus within the cucurbit crop. Virus can have a totally devastating effect in a very short period of time with the potential for total crop loss.

Scenario 2 – Above plus bupirimate, propyzamide

The estimated impact of the loss of active substances in scenario 2 is estimated to be a £20M – 50% reduction in farmgate value.

Bupirimate (£6M – 15%) is used as a control for powdery mildew by many cucurbit growers. The importance with the control of any fungal disorder is to have a resistance strategy identified- and myclobutanil is also lost in scenario 2 this is likely to become very challenging if the products are lost. It is estimated that there will be a 30% reduction in yield if both products are lost.

Propyzamide (£2M – 5%) is one of the few herbicide approvals for courgettes and an essential component to gain a broad spectrum weed control. Poor weed control in courgettes leads to yield loss and competition creates fruit distortion

Scenario 3 – Above plus glufosinate ammonium

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £21M – 51% reduction in farmgate value.

Glufosinate ammonium (£0.5M – 1%) is used in land preparation prior to crop establishment and provides a clean starting point. It is of particular importance in drilled pumpkin crops where the herbicide availability is extremely limited and the crop is treated at the last moment before emergence other products are less favourable at this stage. Failure to control weeds in this situation would lead to small unsaleable pumpkins.

Conclusion

Disease and weed control in cucurbit crops is essential for production of high quality produce. The vast majority of these crops are sold through the high street multiples and the competitive environment and precise standards created requires high quality crop yields to maintain competitiveness.

Fungicide resistance strategies require a portfolio of products to avoid resistance building up. The courgette crop in particular requires treatment close to the harvest period, so long harvest withdrawal periods are of no use. Powdery mildew is one of the largest challenges to growing a cucurbit crop and failure to control it has a dramatic impact, resulting in up to 30% crop yield loss. The loss of active substances indicated through scenarios 1, 2 and 3 give over a 50% loss in farmgate value, questioning the economic viability of continuing to sustainably produce the crop in the UK. With losses in yields supermarkets will seek to replace any fluctuations in production with imports from outside the UK, and increase reliance on imports.

If the products approved for use on courgette and other cucurbit crops were to be categorised as endocrine disruptors, and if this group of materials is withdrawn from the market it will have a severe effect on production of these crops in the UK. Courgette crops in particular are responsible for a large number of jobs particularly within the planting, harvest and onward distribution of this crop within the fresh produce supply chain. The impact of removing adequate crop protection products would have an impact on the job availability within the rural economy.

Sweetcorn

There are approximately 2,000 ha of sweetcorn grown in the UK, with an estimated farmgate value of £10M.

Scenario 1 – None

Scenario 2 – None

Scenario 3 – Terbuthylazine, lambda-cyhalothrin

The estimated impact of the loss of active substances in scenario 3 is estimated to be a £3M – 29% reduction in farmgate value.

Terbuthylazine (£2.5M – 25%) is a major herbicide used in combination with either bromoxynil or mesotrione. This product is used for early post emergence weed control when yield losses are significant from weed competition. Yield losses are acute where young crops are outcompeted by weeds, leading to significant loss in marketable yield. Yield losses of up to 25% would be expected as the alternative products are very limited.

Lambda-cyhalothrin is used for Frit fly control. This pest occurs as a problem on 10% of the sweetcorn area. Where Frit fly occur yield losses are very significant and average losses are 40%.

Conclusion

Loss of both **terbuthylazine** and **lambda-cyhalothrin** would have a significant effect on sweetcorn production in the UK with an expected financial loss indicated. Sweetcorn in the UK is chiefly grown for sale as a fresh product and the implication of crops being either outcompeted by weeds and the prospect of crops being downgraded by pest would have considerable impact on net farm revenues as the customer requirement for this crop is exacting. Sweetcorn supports a large number of jobs within the farms that grow the crop from permanent farm positions, to a large number of summer seasonal roles involved in both the harvest and onward processing of the crop.

Margins on vegetable farms are being squeezed by the competitive nature of the current marketplace and the requirement to grow high quality crops of fresh, healthy produce are paramount at this time. Vegetable growing enterprises such as sweetcorn may appear small scale compared to some larger crops grown on a vast scale, but these crops have a significant role on employment in rural economies.

Outdoor Salads

The total farmgate value of the outdoor salad crop group (baby leaf brassicas, celery, herbs, lettuce, radish and spinach) is estimated at £289M per year (Table 17), with 14,300 ha of outdoor crops grown each year. The largest crop in terms of area grown and value is the lettuce crop at £157M per year, with the herb crop accounting for a further £85M.

Table 17 Summary of economic losses £M - based on yield loss only, in outdoor salad crops across the three scenarios of endocrine disrupting pesticide loss

		Baby Leaf brassica	Celery	Herbs	Lettuce	Radish	Spinach	Outdoor salads
Crop area	**(ha)**	**875**	**885**	**4,000**	**5,894**	**800**	**1,841**	**14,295**
Production	**(t)**	**4,370**	**50,800**	**22,000**	**115,500**	**17,600**	**16,500**	**226,770**
Farmgate value	**(£M)**	**£9**	**£32**	**£85**	**£141**	**£10**	**£13**	**£289**
Scenario 1	Fungicides	£2	£0	£1	£33	£0	£0	**£36**
Scenario 1	Herbicides	£0	£9	£5	£0	£0	£0	**£14**
Scenario 1	Insecticides	£1	£0	£2	£0	£0	£1	**£4**
Scenario 1	All pesticides	£3	£9	£8	£33	£0	£1	**£54**
Scenario 2	Fungicides	£2	£5	£1	£33	£0	£0	**£41**
Scenario 2	Herbicides	£1	£9	£5	£14	£0	£0	**£30**
Scenario 2	Insecticides	£2	£3	£2	£21	£0	£3	**£31**
Scenario 2	All pesticides	£5	£17	£8	£68	£0	£3	**£101**
Scenario 3	Fungicides	£2	£8	£2	£40	£0	£2	**£55**
Scenario 3	Herbicides	£1	£9	£6	£46	£0	£4	**£67**
Scenario 3	Insecticides	£5	£10	£2	£71	£2	£6	**£95**
Scenario 3	PGR	£0	£0	£0	£0	£0	£0	**£0**
Scenario 3	All pesticides	£8	£27	£10	£141	£2	£12	£218

Scenario 1 – Iprodione, mancozeb, prochloraz, linuron, abamectin, cypermethrin

The overall loss of value in the outdoor salad crop from scenario 1 is estimated at £54M - 19%. The largest impacts of the losses in scenario 1 would come as a result of the loss of **mancozeb** (£23M – 8%) and to a lesser extent **prochloraz** (£8M – 3%), especially for the control of downy mildew in ***lettuce*** resulting in a £28M -20% reduction in farmgate value of the crop. Loss of **linuron** (£14M – 5%) for the control of weeds would reduce the value of ***celery*** £9M - 30% and some ***herb crops*** £5M - 6%.

Scenario 2 – Above plus difenoconazole, propyzamide, deltamethrin

The overall loss of value in the outdoor salad crop as a result of the losses of active substances in scenario 2 are estimated at £101M - 35%. The largest additional impacts come as a result of reduced pest control following the loss of **deltamethrin** in ***lettuce*** (£21M - 15%), ***spinach*** (£2M - 15%) and ***celery*** (£3M - 10%). In addition a loss of **propyzamide** will reduce weed control and subsequently yield in ***lettuce*** (£14M - 10%) and ***baby leaf brassicas*** (£1M - 10%).

Scenario 3 – Above plus fosetyl, aluminium, mandipropamid, thiram, chlorpropham, dimethenamid-P, lenacil, S-metolachlor, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat

The total reduction in farmgate value of the outdoor salad crop in scenario 3 is estimated to be £218M - 70%. In reality with the high levels of expected yield losses in this scenario many growers would actually completely cease production and therefore the actual reduction in farmgate value of the crop would be greater. ***Lettuce*** would become completely uneconomic to grow, with the loss of pest control alone expected to result in the value being reduced by at least £70M - 50%. Reduced weed control in ***lettuce*** could reduce the value by £46M – 33% and reduced disease control by £40M – 28%, combined it would be impossible to grow a conventional crop of lettuces. ***Baby leaf brassicas***, ***celery*** and ***spinach*** would be similarly affected, all becoming uneconomic to produce conventionally. In ***herbs*** although the yield losses may not appear as great as for the other crop the economic viability of the crop would be severely compromised as any disease symptoms or insect damage can make the crop unmarketable, increasing the risk of crop rejection.

Baby Leaf Brassica

There are approximately 875 ha of baby leaf brassica grown in the UK, with an estimated farmgate value of £8.7M.

Scenario 1 – Iprodione, mancozeb, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £3M – 31% reduction in farmgate value.

Iprodione (£0.9M – 10%) is used for the control of leaf spots (*Alternaria spp*). **Mancozeb** (£0.9M – 10%) is important in maintaining the effectiveness of other active substances by reducing the risk of resistance to downy mildew.

The loss of **cypermethrin** (£0.9M – 10%) would seriously reduce the ability to the control of caterpillar, leaf miner and flea beetle.

Scenario 2 – Above plus deltamethrin, propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £5M – 51% reduction in farmgate value.

The loss of both cypermethrin and **deltamethrin** (£0.9M – 10%) would have serious consequences for growers and reduce the ability to control caterpillars and flea beetles.

The loss of **propyzamide** (£0.9M – 10%) would make weed control very difficult and there would be an increase in contamination of salad packs with weeds.

Scenario 3 – Above plus fosetyl-aluminium, mandipropamid, propyzamide, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be an £8M – 92% reduction in farmgate value.

Downy mildew is the most serious disease of these crops, the loss of **fosetyl-aluminium** (£0.4M – 5%) and therefore its mixture with propamocarb plus mancozeb and **mandipropamid** would seriously reduce the growers' ability to control downy mildew outbreaks.

The combined losses of cypermethrin, deltamethrin and **spinosad** (£1.3M – 15%) would mean the control of caterpillar, flea beetle and leaf miner would not be possible. The loss of **spirotetramat** (£0.9M – 10%) would reduce the ability to control aphids and increase the use and likelihood of resistance to and residues of pirimicarb the only remaining aphicide.

Conclusion

The total losses under scenario 3 would be around 92% of total crop output, £8M and would seriously damage any possible future production of these crops. At these levels the risks would be considered too high to for growers to continue production and would cause growers to cease production putting at risk 250 associated jobs.

Celery

There are approximately 885 ha of celery grown in the UK, with an estimated farmgate value of £32M.

Scenario 1 – Linuron, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £9M – 30% reduction in farmgate value.

Linuron (£9M – 30%) is the single most effective herbicide used on celery and is used on 100% of the crop grown in the UK, whilst there are some other active substances approved, linuron provides the basis of weed control and there are no obvious replacements at present. Celery is difficult to inter-row hoe due to the narrow rows and soft nature of the petioles which are susceptible to damage. The crop is slower growing than lettuce and can be out competed by fast growing weeds such as fat hen and nettle. It would be a very serious economic loss to the crop, indeed the loss of this single active would threaten the future of celery production in the UK.

Scenario 2 – Above plus difenoconazole, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £17M – 55% reduction in farmgate value.

Celery late blight (*Septoria apiicola*) is the single most destructive disease of celery. In high pressure seasons it can lead to the complete loss of the celery crop. **Difenoconazole** (£5M – 15%) is the most effective fungicide for septoria control in celery. In fact only two active substances are approved: - difenoconazole and azoxystrobin. The loss of difenoconazole would leave only azoxystrobin for control of septoria. Azoxystrobin offers a reduced level of control and would leave growers unable to meet FRAG guidelines on the use of strobilurins. Resistance would not take long to appear.

Deltamethrin (£3M - 10%) is widely used for the control of caterpillar and capsid, caterpillar feed both on the leaves and on the petioles, capsids generally feed on the petioles and in the growing points. The loss of deltamethrin would cause considerable loss of quality and yield reducing harvestable yield considerably especially in hot dry seasons.

Scenario 3 – Above plus thiram, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £27M – 86% reduction in farmgate value.

The effects of scenario 3 is to severely increase the risk to crop loss from septoria by removing the only approved effective seed treatment (**thiram** - £3M – 10%) combined with the most effective foliar fungicide (**difenoconazole**). Whilst seed hygiene is important seed borne transmission can never be ruled out and only a tiny level of initial infection would lead to considerable crop losses. Most celery seed is produced in Europe in Italy, France, Holland and the UK, seed mother plant production would be largely unprotected from septoria transmission and the likelihood of seed borne infection would be very high.

The combined losses of **deltamethrin, lambda-cyhalothrin** (£3M – 10%) and **spinosad** (£3M – 10%) would mean there would be no effective control of caterpillars or capsid. Both pests are capable of rendering a celery crop completely unmarketable and the combination of both would make summer and autumn production extremely risky.

Conclusion

Scenario 1 - This would cause a significant - £9M loss to UK celery growers, around 30% of total crop value, because of the complete inability to effectively control weeds because of the loss of **linuron**. Production costs would treble due to the need for hand weeding (not captured in these figures).

Scenario 2 - The loss of **difenoconazole** would render septoria control very difficult as it would leave only a single active, which at best gives moderate control and would increase the risk of resistance to septoria and the occurrence of pesticide residues in the crop. This scenario would include the loss of **deltamethrin** which is very important for the control of caterpillar and capsid; both serious pests of celery in the summer months.

Total reduction in farmgate value under scenario 2 is equivalent to £17M - 55% of total crop value.

Scenario 3 - In scenario 3 septoria control becomes even more difficult due the loss of the most effective seed treatment together with the most effective foliar fungicide from scenario 2.

The control of caterpillar and capsid becomes impossible, which at times would lead to complete crop loss for several weeks during the summer.

Total losses in scenario 3 come to 85% of total crop output, some £27M. Summer and autumn production would become unsustainable. Some production under covers earlier in the season may be possible, but production costs would be extremely high due to the need to removed covers for hand weeding. Estimated job losses would be 360 employees.

Herbs

There are approximately 4,000 ha of herbs grown in the UK, with an estimated farmgate value of £85M.

Scenario 1 – Iprodione, mancozeb, prochloraz, linuron, abamectin and thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be an £8M – 10% reduction in farmgate value.

Mancozeb (£0.5M – 1%) is the only currently approved active substance with multi-site protection capability – considered an essential component in downy mildew prevention.

It is considered that Sage and Tarragon could not be grown economically without **prochloraz** (£0.8M – 1%).

Linuron (£5M – 6%) is a widely used basic pre-emergence herbicide for umbelliferous herbs (coriander, dill, parsley etc.). The crop has been highly dependent on the substance for decades and the wide range of controlled weeds plus lack of crop phytotoxicity have ensured linuron remained an integral element of weed-free umbel Herb production. The loss of this would be catastrophic for the crop.

Abamectin (£1.5M – 2%) No alternative is as effective for spider mite and thrips control under current authorisation. Loss of control would be damaging.

Scenario 2 – Above plus propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be an £8M – 10% reduction in farmgate value.

The loss of **propyzamide** (£0.2M – 0.5%) would be particularly significant as it is the only substance with current product authorisation for use in weed control of herb crops under protection. Propyzamide also has a significant role in early spring for perennial herbs.

Scenario 3 – Above plus fosetyl ammonium, mandipropamid, chlorpropham, lenacil, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £10M – 12% reduction in farmgate value.

Loss of **lenacil** (£0.8M – 1%) would be another major issue and will severely restrict pre-emergence options for Mint and seed sown labiate herbs. **Lenacil** has been a very effective pre-emergence controller of weeds in labiate herbs with no alternative currently available.

In this scenario there are a number of key substances that would be a major loss to the UK herb grower. In particular **mandipropamid** (£0.5M – 1%) is an effective substance particularly for herb downy mildew control. The insecticides listed above are effective in providing a range of modes of action for best practice production of Herbs, but this will be severely restricted if the active substances were to be removed from use, with no tools remaining for the increasing difficulty of Thrips control. Overall this list would decimate the economic production capability of Herbs in the UK.

Conclusion

The UK herb season is already constrained by day length and climate with a heavy reliance on imports to satisfy the all year round demand. Judicial use of chemical tools with varying modes of action has become a cornerstone of integrated crop management options for UK herb growers, but many of these principles will not be applicable with the losses listed above. The loss based on above data was considered to be over **£10M -** which does not include a number of substances for which loss data were not readily available); some industry estimates calculate the impact may be over **£33M** - based on loss of farm income. As leaf products, culinary herb crops cannot be harvested for sale if they are blemished by disease symptoms, insect damage or weed contamination. The economic viability of most UK herb production would likely be lost should the above substances be withdrawn resulting in a shut-down of large area of UK herbs.

Lettuce

There are approximately 5,900 ha of lettuce grown in the UK, with an estimated farmgate value of £141M.

Scenario 1 – Iprodione, mancozeb, prochloraz, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £33M – 23% reduction in farmgate value.

The most serious loss would be that of **mancozeb** (£21M – 15%), which has an important role in the control of downy mildew, as almost the only active which has no known resistance, due to its unique multi-site activity. The loss of mancozeb would increase the use of strobilurins and single site active substances, which are very prone to showing resistance. Whilst plant breeding can produce lettuce varieties with some resistance to mildew this tends to be short lived due to the ability of this disease to adapt and overcome genetic plant resistance. The loss of **iprodione** (£4M - 3%) and **prochloraz** (£7M - 5%) would increase in losses due to botrytis and ring spot.

Scenario 2 – Above plus propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £68M – 48% reduction in farmgate value.

The losses of **propyzamide** and **deltamethrin** which are both important active substances in lettuce production. **Propyzamide** (£14M – 10%) provides useful control of grasses and some broadleaf weeds and is particularly useful on very light textured soils because of its good crop safety profile. Good control of caterpillars and especially silver-y moth is essential in lettuce, both from the contamination of heads with bodies and frass and feeding damage to the leaves. The loss of **cypermethrin** recently, together with the potential loss of **deltamethrin** (£21M – 15%) would have serious consequences for lettuce growers.

Scenario 3 – Above plus fosetyl-aluminium, mandipropamid, thiram, chlorpropham, dimethenamid-P, S-metolachlor, lambda-cyhalothrin, spinosad, spirotetramat

The combined losses of the active substances in scenario 3 would mean that lettuce production in the UK would become unsustainable with complete loss of production anticipated.

With the loss of **mancozeb**, **fosetyl-aluminium** and **mandipropamid** this will significantly increase the crop losses from downy mildew, the single most important disease of lettuce. The loss of mancozeb also means the lifespan of other active substances that are susceptible to resistance and often used in conjunction with mancozeb, will be reduced, this includes; metalaxyl-m, some of the strobilurins, azoxystrobin, dimethomorph and

propamocarb. The loss of iprodione, prochloraz and **thiram** increase losses from botrytis and ring spot. The total reduction in value due to poor disease control is estimated at £42M – 28%.

The losses of **chlorpropham**, **propyzamide**, **dimethenamid-p** and **s-metolachlor** would increase losses from weed competition and leave only pendimethalin, which is a useful active, but inadequate on its own give complete weed control. There would be no control for groundsel, which would mean some sites would be unable to produce lettuce economically. Losses of the other herbicides would encourage increased use of pendimethalin which could have implications for crop safety, the environment and crop pesticide residues. The total reduction in value due to poor weed control is estimated at £46M – 33%

There would be a complete lack of any control of caterpillars which are a serious pest especially in hot dry summers. They cause significant leaf damage and in addition spoil crop with their waste and bodies, cutworm is also a serious pest of lettuce and whilst some control is offered through irrigation additional crop damage by cutworm is also likely. Reduced aphid control, especially the currant-lettuce aphid with the loss of **spirotetramat**, is likely to lead to increased crop spoilage and infested heads in the summer months. This would also mean increased usage of alternative products such as the neonicotinoids. Such use would hasten the spread of aphids resistant to these alternative active substances and increase the risks of crops having pesticide residues of the remaining active substances. The total reduction in value due to poor pest control is estimated at £71M – 50%.

The total effect under scenario 3 is a complete, loss of lettuce production as the crop would become unsustainable.

Conclusions

Scenario 1 - This would cause a significant - £33M loss to UK lettuce growers, around 23% of total crop value, mainly by increasing losses from downy mildew due to the loss of **mancozeb** and the increase in losses from botrytis and ring spot with the losses of **iprodione** and **prochloraz.**

Scenario 2 - This scenario would include the loss of **deltamethrin** which is very important for the control of caterpillar a serious pest of lettuce in the summer months. The loss of **propyzamide** makes weed control difficult especially in light textured soils, as there are also no specific graminicides approved for lettuce, so the control of grass weeds becomes poor. Total losses under scenario 2 are £71M - around 50% of total crop value.

Scenario 3 - With the loss of all these key active substances the production of lettuce in the UK becomes unsustainable. The risk of economic loss would be higher than the total economic output, at which point no one would be prepared to take the risks involved in

producing the crop. Therefore lettuce would be imported from countries outside the EU that are not subject to such restrictive practices. Total losses under scenario 3 exceed the estimated total farmgate value of £141M so 100%. The job losses associated with this loss would be in the order of 5500.

Radish

There are approximately 800 ha of radish grown in the UK, with an estimated farmgate value of £10M.

Scenario 1 – Iprodione

The impact of the loss of active substances in scenario 1 is estimated to be a £0.2M – 2% reduction in farmgate value.

The loss of **iprodione** seed treatment would expose crops to greater losses from such diseases as alternaria although the impact would be relatively small (2% reduction in farmgate value).

Scenario 2 – No additional losses

Scenario 3 – Above plus thiram, chlorpyrifos, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £2.3M – 24% reduction in farmgate value.

Thiram (£0.2M – 2%) is used as a seed treatment for damping-off diseases such as pythium. There are currently no alternative fungicide seed treatments for radish.

Chlorpyrifos (£1.0M – 10%) is used post-drilling, pre-emergence for the control of cabbage root fly. This is the only active available for cabbage root fly control. This is the most devastating pest of radish, rendering them unmarketable due to root mining. Crop mesh covers are already used on much of the crop, although control is not perfect.

Lambda-cyhalothrin (£1.02M – 10%) is the only post emergence insecticide approved for radish to control flea beetle and caterpillar. Important for maintaining leaf quality on bunched radish.

Conclusion

Scenario 1 - Relatively minor impact for the radish crop.

Scenario 2 – No additional impact.

Scenario 3 - Serious impact for the radish crop, with large potential losses from cabbage root fly, flea beetle and caterpillars.

Spinach

There are approximately 1,840 ha of spinach grown in the UK, with an estimated farmgate value of £12.5M.

Scenario 1 – Cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £1.2M – 10% reduction in farmgate value.

Cypermethrin (£1.2M – 10%) is used for the control of caterpillars and flea beetle. Spinach is grown mainly as a baby leaf crop for salad packs, leaf holing damage is unacceptable and crops with leaf holing would be rejected.

Scenario 2 – Above plus deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £3.1M – 25% reduction in farmgate value.

Deltamethrin (£1.9M – 15%) is widely used in spinach (90% of the crop), for the control of caterpillars and flea beetles, favoured due to short harvest interval and good residue profile. Other active substances are also used, but in high pressure years for the silver-y moth (*Autographa gamma*), repeated applications are required and all the current active approvals used are often inadequate to give complete control of this very destructive pest.

Scenario 3 – Above plus fosetyl aluminium, mandipropamid, thiram, chlorpropham, lenacil, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £12M – 96% reduction in farmgate value.

Downy mildew is the most serious of the spinach disease, the loss of **fosetyl aluminium** (£1.9M – 15%) and therefore its mixture with propamocarb would seriously reduce the growers' ability to control downy mildew outbreaks.

The loss of **lenacil** (£3.4M – 25%) and **chlorpropham -** £1.3M – 10%) would make weed control very difficult and there would an increase in contamination of salad packs with weeds. Some of these weeds such as groundsel (*Senecio vulgaris*), and the nightshades are toxic if consumed raw as contaminants in salad packs. Others such as nettles (*Urtica dioica*) are merely unpleasant raw. As spinach is machine harvested as a whole crop complete removal of these contaminant weeds would be most difficult.

The combined losses of **cypermethrin**, **deltamethrin** and **spinosad** (£1.3M – 10%) would mean the control of caterpillar and leaf miner would not be possible. The loss of **spirotetramat** (£1.3M – 10%) would reduce the ability to control aphids and increase the

use and likelihood of resistance to and residues of pymetrozine and acetaprimid the only remaining aphicides.

The total losses under scenario 3 would be around 96% of total crop output, £12M and would seriously damage any possible future production of the crop. At these levels the risks would be considered too high to for growers to continue production and would cause the loss of the crop and 250 associated jobs.

Conclusion

Scenario 1 - Relatively small number of ingredients, although the loss of cypermethrin would cause potentially serious problems**.**

Scenario 2 - The loss of both cypermethrin and deltamethrin would severely impact on the ability to control insect pests.

Scenario 3 - The crop becomes unsustainable due to the inability to control weeds (including toxic weeds), downy mildew and pests. Loss of output of £12.1M and the associated loss of 250 jobs.

Protected Edibles

The total value of the protected edible crop group is estimated at £181M per year (Table 18). Based on the expert summaries of the individual crops in this crop group it is estimated that a loss of the approved active substances in scenario 1 would cost the crop group £7M – 4% in reduced yield, with largest losses in ***tomato*** (£3M – 3%), with a loss of the insecticide **abamectin** expected to cause the greatest loss of yield. In scenario 2 the yield cost to the crop group would rise to £22M – 12%, with the largest losses in the ***cucumber*** (£9M – 19%) and ***tomato*** (£7M – 7%) crops. In ***cucumber*** the largest losses are as a result of a loss of **bupirimate** and subsequent challenges controlling powdery mildew. In scenario 3 the yield cost to the protected crop group is estimated at £49M - 27%, with the largest losses from protected lettuce (£14M – 100%), tomato (£13M – 14%) and cucumber (£11M – 22%). The yield losses in protected lettuce relate to a loss of **fosetyl aluminium** and to a lesser extent **mandipropamid** and subsequent inability to control downy mildew.

Table 18 Summary of economic losses £M - based on yield loss only, in protected edible crops across the three scenarios of endocrine disrupting pesticide loss (crop areas/values based on 2012 Defra Hort Stats areas)

		Cucumber	Protected peppers	Protected salads leaves	Protected salads lettuce	Tomato	Protected edibles
Crop area	**(ha)**	**115**	**85**	**213**	**213**	**204**	**830**
Production	**(t)**	**63,300**	**21,300**	**660**	**6,600**	**83,000**	**174,860**
Farmgate value	**(£M)**	**£50**	**£19**	**£1**	**£14**	**£97**	**wheat1**
Scenario 1	Fungicides	£1	£0	£0	£1	£0	**£3**
Scenario 1	Herbicides	£0	£0	£0	£0	£0	**£0**
Scenario 1	Insecticides	£1	£1	£1	£0	£3	**£5**
Scenario 1	All pesticides	£2	£1	£1	£1	£3	**£7**
Scenario 2	Fungicides	£8	£0	£0	£1	£1	**£11**
Scenario 2	Herbicides	£0	£0	£0	£1	£0	**£1**
Scenario 2	Insecticides	£1	£3	£1	£0	£6	**£10**
Scenario 2	All pesticides	£9	£3	£1	£2	£7	**£22**
Scenario 3	Fungicides	£10	£0	£1	£11	£1	**£23**
Scenario 3	Herbicides	£0	£0	£0	£1	£0	**£1**
Scenario 3	Insecticides	£1	£7	£2	£3	£12	**£25**
Scenario 3	All pesticides	£11	£7	£3	£14	£13	£47

Scenario 1 – Iprodione, mancozeb, myclobutanil, abamectin, thiacloprid

For most crops the loss of pesticide active substances in scenario 1 is sustainable, with the estimated impact on the crop group being a £7M - 4% reduction in farmgate value. It will result in some reductions in yield, and there will be increased costs associated with production, occasional small producers will suffer localised challenges (e.g. high incidence of a particular pest) may cease production. In protected crops the biggest disease challenges following the withdrawal of fungicide active substances will be powdery mildew and downy mildew control. In scenario 1 control is often weakened through the loss of a part of the resistance strategy (**mancozeb** for downy mildew in protected salads and **myclobutanil** for powdery mildew control in cucumber) reducing the value of protected edibles by £3M - 1%. However, the loss of insecticides and subsequent reduction in control is expected to have greater impacts costing the crop group £5M - 3%) in reduced value.

Scenario 2 – Above plus bupirimate, thiophanate-methyl, propyzamide, deltamethrin, spiromesifen

The additional losses in scenario 2 will make production increasingly less viable with cucumber and protected salad producers in particular expected to cease production due to reduced yields and increased costs of production. The estimated reduction in farmgate

value of the crop group is £22M - 12%. In cucumber the loss of **bupirimate** is estimated to reduce the value of the crop group £7.5M - 15%s. The loss of **spiromesifen** in protected peppers would reduce two-spotted spider mite control, resulting in an estimated reduction in farmgate value of £2M - 11%.

Herbicides are not widely used in protected crops, except in the soil grown protected salads. Loss of propyzamide leaves no alternative chemical control option.

Scenario 3 – Above plus fosetyl ammonium, mandipropamid, lambda-cyhalothrin, spinosad, spirotetramat

Total losses to the protected salads crop group under scenario 3 are estimated at £47M - 26%, although where businesses cease production the actual loss would be greater as these businesses would see a complete loss of production on their area. ***Protected salad leaves*** and ***lettuce*** would become completely uneconomic to grow and most growers would probably cease production. The ***protected pepper*** crop could reduce in value by £7M - 39%, meaning that for many growers these would also become uneconomic to grow conventionally. The ***cucumber*** and ***tomato*** industries are estimated to reduce in value by £11M - 22% and £13.4M - 14% respectively.

The combined loss of fungicides is estimated to reduce the value of the crop group by £23M - 13% in reduced yields.

The loss of insecticides is estimated to reduce the value of the protected crops group by £25M - 14% as a result of yield losses. This is predominantly as a result of reduced two spotted spider mite (TSSM) and thrips control, although other pests are also a concern, especially as the number of insecticides reduces through the scenarios. Red-spider mite is controlled by some growers by using biological controls added the glasshouse prior to placing the crop. Where this practice is used it is possible to minimise the requirement for pesticide applications.

The subsequent losses of additional active substances in scenarios 2 and 3 further reduces control and increases the risk of resistance development to the point where cucumbers and protected salads (leaves and lettuce) will suffer such great yield losses that they will be unviable for most growers to continue to produce.

Cucumber

There are approximately 115 ha of cucumber grown in the UK, with an estimated farmgate value of £50.1M.

Scenario 1 – Myclobutanil, abamectin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £2M – 3% reduction in farmgate value.

The loss of **myclobutanil** (£0.8M - 1%) and **abamectin** £1.0M - 2%) in themselves would be a problem. The main concern is the poor powdery mildew control – particularly in the early part of the growing season when myclobutanil is normally used (estimated yield impact 1.5%). The fact that UK growers tend to select powdery mildew tolerant varieties is because of the lack of active substances for control rather than any altruistic reasons of reduced residues. The powdery mildew tolerant varieties still need protection and the removal of myclobutanil removes most of that early protection. It is estimated that in an average year without abamectin, Two Spotted Spider Mite (TSSM) would reduce yields by 2%.

With this level of loss of production there would be a reduction in output that would mean loss of jobs within the crop and an increase in imports from the Netherlands and to a lesser extent Spain (because of the differing periods of production).

Scenario 2 – Above plus bupirimate, deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £9M – 19% reduction in farmgate value.

Bupirimate (£7.5M – 15%) is used from the middle of the second crop onwards (usually) to control severe outbreaks of powdery mildew. Assuming a "normal" level of powdery mildew is present and it could not be controlled the losses could be high and would be total in some cases. Loss of bupirimate, in addition to myclobutanil, would reduce yields by 10 -20%. The loss of bupirimate in addition to myclobutanil, leaves only cyflufenamid for powdery mildew control and that is restricted to two applications per crop of very low amounts of active. The newer SDHI products that are awaiting approval along with other products with CRD could redress the balance – but the new products need to be made available before the highlighted products are withdrawn.

With both powdery mildew control active substances removed and with nothing to replace them many cucumber growers will choose (or be forced) to move to other crops or to cease growing altogether. This will mean a further reduction in jobs in the crop and yet more imports.

Scenario 3 – Above plus fosetyl ammonium, thiram

The impact of the loss of active substances in scenario 3 is estimated to be an £11M – 22% reduction in farmgate value.

Fosetyl ammonium (£1.5M – 3%) is approved only in mixture with propamocarb hydrochloride and as propamocarb hydrochloride is not approved alone the removal of fosetyl aluminium would remove both products. This product combination is the only approved active ingredient for *Pythium* control. The amount of *Pythium* is usually greatest in the re-planting periods from May to August when losses can be high as whole plants are lost. The reduction in farmgate value varies between sites and seasons, but could amount to 3% of the crop.

The combined losses in scenario 3 mean there would be little incentive to grow "conventional" cucumbers any more. The demand for organics is not that great and if all existing growers moved to organic production there would be insufficient demand to maintain production.

Conclusion

Cucumber consumption is starting to increase (driven by a lower retail pricing policy by the multiples – and an increasing population) so there is an opportunity and need to produce more UK cucumbers to meet customer demand which in turn will increase farmgate values, secure jobs, generate growth and improve UK food security. However, growers are not going to invest in facilities to meet this demand if there is an inability to protect their investment i.e. their crop. The removal of the products listed under the ED review will remove the same products across the EU, but the impact in the UK will be much greater than elsewhere, because we do not have the same range of active substances available in other member states.

The removal of all the active substances in scenario 3, without suitable replacement products, would see the decline of the cucumber crop in the UK.

Protected Pepper

There are approximately 85 ha of protected peppers grown in the UK, with an estimated farmgate value of £19M.

Scenario 1 – Abamectin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £1M – 3% reduction in farmgate value.

The loss of **abamectin** (£0.5M – 3%) and **thiacloprid** (£0.1M – 1%) would leave growers with few, if any, sustainable 'clean up' insecticide options at the end of the growing season. Although neither active ingredient is used by growers during the cropping season, these active substances remain important to growers for overwinter control of Western Flower Thrips and Two spotted spider mite, prior to planting new crops. This would pose a threat

to pepper crops in the early part of the season as overwintered insect pests could have detrimental impacts on young plants. Growers would have to rely on less effective chemical controls to 'clean---up' greenhouses post production and also increase expenditure on Integrated Pest Management (IPM) systems to control insects such are Two Spotted Spider Mite in the early part of the season.

Scenario 2 – Above plus deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £3M – 14% reduction in farmgate value.

The loss of **spiromesifen** (£2M – 11%) would cause significant economic loss to protected pepper growers in the UK under scenario 2. Although beneficial insects are widely used to control two spotted spider mite in peppers on many occasions and certainly where greenhouse temperatures reach 25-30 ^{O}C populations can become very difficult to control, using predators. In this scenario growers would have to use chemical controls to 'spot-treat' areas of the pepper crops infected with spider mite. The mode of action along with the lack of cross-resistance to commercial products makes the active ingredient a useful tool in IPM and resistance management strategies in the greenhouse.

Scenario 3 – Above plus lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £7M – 39% reduction in farmgate value.

The loss of **spinosad** (£4.5M – 24%) to UK protected pepper production would cause the biggest economic impact on the wider industry. Spinosad is an important insecticide not only because it plays a key role in controlling insects pests such as Onion thrips where control is lost through the use of bio control agents such as *Amblyseius* and *Orius* sp, but also in resistance management. Spinosad is used widely at the latter end so the season – September / October to control invasive caterpillar pests such as *Noctuid* and *Mamestra* species as well as Silvery Y moth (*Autographa gamma*). These types of caterpillars can be highly damaging to pepper crops. Economic damage is expressed in two principal ways; direct feeding and contamination. This can mean that growers would rely on increased labour to carefully harvest and select peppers as well as having to incur potential financial penalties in rejected product and in a worst case scenario having to rely on imported fruit to cover losses.

Conclusion

Protected pepper production using IPM techniques would become increasingly difficult in the absence of thiacloprid from scenario 1. Where IPM control of two spotted spider mite

the loss of abamectin in scenario 1 and spiromesifen in scenario 2 would leave no control options. However the largest impact on the crop would come as a result of the loss of spinosad in scenario 3 for the control of onions thrips and caterpillar species. There would be increased costs of harvesting (not captured) and increased rejections due to contamination or damage.

Protected Salad – Leaves

There are approximately 210 ha of protected salad leaves grown in the UK, with an estimated farmgate value of £1.4M.

Scenario 1 – Iprodione, mancozeb, abamectin

The impact of the loss of active substances in scenario 1 is estimated to be a £0.9M – 60% reduction in farmgate value.

The loss of **mancozeb** (£0.1M – 10%) alone will not be a significant loss relative to downy mildew control, but cumulatively with the loss of other active substances it could be very serious: Downy mildew can render a crop unmarketable.

Abamectin (£0.7M – 50%) is crucial for leaf miner control where continuous cropping is practised as pests can build up rapidly in multiple cropping situations. Biological controls are not effective against *Scaptomyza,* nor can they prevent feeding marks on leaves where the market requirement is for unmarked leaves.

Scenario 2 – Above plus propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £1.0M – 67% reduction in farmgate value.

Propyzamide (£0.1M – 10%) is the only effective approved herbicide. The loss of propyzamide would require hand weeding or soil sterilization to be implemented. Chickweed grows under protection faster than lettuce and begins production of seed shortly after germination. Hand weeding would achieve only partial control. The loss would add considerable cost and reduction in quality and yield for crops grown in soil.

Scenario 3 – Above plus fosetyl ammonium, mandipropamid, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £1.4M – 100% reduction in farmgate value.

Loss of **fosetyl aluminium** (£0.4M – 25%) and **mandipropamid** (£0.4M – 25%) might render production of protected lettuce leaves and Crucifers unviable during high disease risk periods, due to the risk of uncontrolled Downy mildew infection. This would render the

production of some leaf types unviable throughout the year without alternatives being available.

Spirotetramat is valued for control of late infestations of aphid and as part of a pest resistance strategy.

Caterpillars and Leaf Miners are periodically serious pests and **lambda-cyhalothrin** (£0.4M – 25%) will be the only potent pyrethroid available to growers after October 2014. Withdrawal of **spinosad** (£0.4M – 25%) would remove the only other potent insecticide. Alternative products, pyrethrins and Bacillus do not have persistence and require frequent application for caterpillar control and do not control Leaf Miners.

Conclusion

If the production of these leaves is rendered unviable some growers will be able to grow alternative crops, but due to the specialist nature of horticultural production and sales, many either cannot or will not continue; there will be a loss of employment. These products are demanded by the public and will be imported, but often of lower quality due to the increased shipment times.

Protected Salad – Lettuce

There are approximately 210 ha of protected salad lettuce grown in the UK, with an estimated farmgate value of £14M.

Scenario 1 – Iprodione, mancozeb

The impact of the loss of active substances in scenario 1 is estimated to be a £1.4M – 10% reduction in farmgate value.

The loss of **mancozeb** (£1.4M – 10%) alone will not be a significant loss relative to Downy mildew control but cumulatively with the loss of other active substances it could be very serious: Downy mildew can render a crop unmarketable.

Scenario 2 – Above plus propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £2.2M – 16% reduction in farmgate value.

Propyzamide (£0.8M – 6%) is the only effective approved herbicide. The loss of propyzamide would require hand weeding to be implemented to supplement use of polythene sheeting. Chickweed grows under protection faster than lettuce and begins production of seed shortly after germination. Hand weeding would achieve only partial control. Resulting in loss of quality and yield whilst adding significant cost to production.

Scenario 3 – Above plus fosetyl ammonium, mandipropamid, chlorpropham, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £14M – 100% reduction in farmgate value.

Loss of **fosetyl aluminium** (£7M – 50%) and **mandipropamid** (£3M – 20%) could render production of protected lettuce unviable during high disease risk periods due to the risk of uncontrolled Downy mildew infection. When combined with the loss of mancozeb this would render the crop unviable throughout the year without alternatives being available.

Caterpillars are periodically serious pests and **lambda-cyhalothrin** (£2M - 15%) will be the only potent pyrethroid available to growers after October 2014. Withdrawal of **spinosad** (£0.7M - 5%) would remove the only other potent pesticide. Alternative products e.g. pyrethrins and *Bacillus* do not have persistence and require frequent application.

Conclusion

The British Leafy Salads Association (BLSA) survey records 385 ha of production most of which is on specialist lettuce nurseries. Were the production of lettuce rendered unviable it is estimated that 1000 jobs will be a risk. Some growers will be able to grow alternative crops, but due to the specialist nature of horticultural production and sales many either cannot or will not continue. The products are demanded by the public and will be imported, but often of lower quality due to the increased duration during shipment.

Tomato

There are approximately 200 ha of tomato grown in the UK, with an estimated farmgate value of £96.7M.

Scenario 1 – Iprodione, maneb, metconazole, abamectin

The impact of the loss of active substances in scenario 1 is estimated to be a £3M – 3% reduction in farmgate value.

The removal of products such as **iprodione** (£0.3M - <1%) and **abamectin** (£2.5M - 3%) will have a direct impact on yield losses and reduce value, but it is the removal of the alternative active substances in any resistance strategies that will present the greatest difficulties in the future.

Scenario 2 – Above plus bupirimate, thiophanate-methyl, deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £7M – 7% reduction in farmgate value.

Spiromesifen (£3M – 3%) is used to control two spotted spider mite (TSSM). The use of full biological control for TSSM would reduce potential losses, over the national crop it is estimated to cost an additional £0.4M - not captured in these figures). Crop loss would still occur and would be greatest in hot bright years, but on average the loss is estimated to be 2.5% plus extra costs.

The loss of **spiromesifen** and **abamectin** together leaves only etoxazole or products with physical action to deal with Red Spider Mite (RSSM) outbreaks where biological control breaks down. The increase in biological control costs and the additional losses of crop would be significant.

Thiophanate-methyl is the only product effective against vascular wilt diseases and whilst these are not widespread (at present) where they do occur they do present a problem that is not easy to overcome.

Scenario 3 – Above plus chlorothalonil, fosetyl ammonium, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £13M – 13% reduction in farmgate value.

The greatest issue will be in trying to control *Tuta absoluta* without **spinosad** (£7M – 7%). The fact that this pest feeds on the fruit as well as the foliage means there are potentially more issues with product at the retailers leading to customer complaints, and subsequent rejections and loss of contracts. Individual sites can lose up to 20% of crop because of the effect on fruit – and total loss of the active would increase the incidence of the pest across the country - total losses assumed to be a conservative 7% for the total crop. Equally any loss of the existing control of *Tuta* would greatly increase the infestations across the country and further increase the losses.

Conclusion

Tomato production area in the UK has declined over the past twenty years from a peak of 523 ha (1992) to 204 ha in 2012. The output has declined in the same period from 122,500t to 83,000t today, however, output per hectare has increased during this period. There is an increasing demand for UK produce – mainly due to a concerted advertising campaign by the Tomato Growers' Association (TGA). To feed this increasing demand for UK produce we do need UK produce.

Investment in tomato production in the UK is starting to increase with a number of high profile projects across the country and there is a need to be able to control the pests and diseases that occur – in older glass as well as any increased area. This requirement includes the need to have a robust resistance strategy in place for all the major pests and diseases encountered. This robust strategy does not exist now for some pests and

diseases and the removal of further active substances will only make the situation worse. This becomes even more of an issue where alien pests are introduced into the UK and require control. Products must be available to cope with the demand for “normal” pests and diseases – but also for the unexpected alien species that fly in or are driven here in temperature controlled vehicles.

Abamectin, **spiromesifen** and **spinosad** are the most significant active substances so far as the majority of UK tomato growers are concerned. With the others identified for a smaller number of growers – but the individual problems become significant for each site affected. The loss of some or all of these active substances would present a major problem to UK tomato growers partly from direct loss of control and partly from loss of active substances in a pest or disease resistance strategy. It is unlikely that growers would choose not to grow tomatoes if some or all the products in the review were removed, but it would increase the costs of biological pest control substantially, pests such as *Tuta* could become a major issue as infestations spread and labour inputs would increase to cope with extra crop work.

Soft Fruit

The total farmgate value of the soft fruit crop group (blackberry, blackcurrant, blueberry, raspberry, rhubarb and strawberry) is estimated at £374M per year (Table 19), with approximately 9,700 ha of soft fruit crops grown each year. The largest crop in terms of area grown and value is the strawberry crop at £222M - per year, with the raspberry crop accounting for a further £90M. These crops have a high retail value and therefore any impacts will be significantly higher at the retail level compared to the farmgate figures presented here.

Table 19 Summary of economic losses £M - based on yield loss only, in soft fruit crops across the three scenarios of endocrine disrupting pesticide loss

		Blackberry	Blackcurrant	Blueberries,	Raspberries - cane fruit,	Rhubarb	Strawberry	Soft fruit
Crop area	**(ha)**	**214**	**2,471**	**344**	**1,616**	**430**	**4,648**	**9,723**
Production	**(t)**	**1,391**	**11,600**	**2,400**	**15,100**	**20,500**	**95,700**	**146,691**
Farmgate value	**(£M)**	**£8**	**£12**	**£15**	**£90**	**£26**	**£222**	**£374**
Scenario 1	Fungicides	£1	£0	£0	£12	£13	£28	**£54**
Scenario 1	Herbicides	£0	£0	£0	£0	£0	£2	**£2**
Scenario 1	Insecticides	£2	£0	£2	£20	£0	£69	**£92**
Scenario 1	All pesticides	£3	£0	£2	£32	£13	£98	**£148**
Scenario 2	Fungicides	£1	£0	£0	£14	£13	£83	**£111**
Scenario 2	Herbicides	£0	£2	£0	£4	£3	£8	**£17**
Scenario 2	Insecticides	£2	£0	£2	£24	£1	£92	**£122**
Scenario 2	All pesticides	£4	£2	£2	£41	£17	£184	**£250**
Scenario 3	Fungicides	£1	£0	£0	£23	£13	£94	**£132**
Scenario 3	Herbicides	£1	£3	£0	£9	£3	£53	**£69**
Scenario 3	Insecticides	£5	£4	£4	£45	£1	£181	**£240**
Scenario 3	All pesticides	£7	£6	£4	£77	£17	£222	£334

Scenario 1 – Iprodione, mancozeb, myclobutanil, tebuconazole, amitrole, abamectin, thiacloprid

The overall impact of lost yield to the soft fruit crop group of losing the active substances in scenario 1 is £148M - 40% of the value of the crop group.

The loss of **iprodione** would reduce the value of the crop group by £22M - 6%, predominantly affecting botrytis control in rhubarb and strawberry. **Mancozeb** is not widely used in the soft fruit crop group, however it is used in ***rhubarb*** production and its loss would be significant resulting in an estimated £8M - 31% reduction in the value of the crop. The combined impacts of losing iprodione and mancozeb would result in rhubarb yields reducing by 50% making large parts of the crop unsustainable.

The loss of **thiacloprid** is expected to cause the largest impact in this scenario accounting for a £58M -16% reduction in farmgate value of the soft fruit crop group. The main crops impacted are ***blackberries*** £2M - 20% and ***strawberries*** £41M - 19%, closely followed by ***raspberries*** £14M - 15%. The loss of **abamectin** would cause serious challenges to two spotted spider mite control with no alternative active substances available, and subsequent loss of value in ***strawberry*** £28M - 13% and ***raspberry*** £6M - 7%, total impact on the crop group would be a £34M - 9% reduction in farmgate value.

In this scenario the yield losses in most crops would be such that serious concerns were raised over the viability of individual businesses, with a proportion of growers expected to cease production. The ***rhubarb*** crop would reduce in value by at least £13M - 50%, more if growers go out of production. The ***strawberry*** crop would reduce in value by £98M - 44%, blackberries and raspberries would reduce in value by £3M and £32M respectively, equivalent to (35%).

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, metribuzin, propyzamide, deltamethrin

The overall impact of lost yield in scenario 2 for the soft fruit crop group is £250M - or 67% of the value of the crop group. The main impacts in this scenario are from a further loss of disease control in ***strawberries*** following the loss of **bupirimate** (£29M – 8%) and **penconazole** (£28M – 7%), and subsequent reductions in powdery mildew control. The loss of **deltamethrin** would reduce the value of the soft fruit crop group by £29M – 8%, with the largest impacts expected in ***strawberries*** (£23M – 11%). The impact could increase across all soft fruit crops if spotted winged drosophila becomes further established as deltamethrin is an important tool in the control of this non-native pest. The loss of **propyzamide** is estimated to reduce the value of the soft fruit crop group by £14M – 4%, reducing weed control in most crops.

Scenario 3 – Above plus fluazinam, fosetyl aluminium, fluazifop-P-butyl, glufosinate ammonium, lenacil, chlorpyrifos, lambda-cyhalothrin, spinosad

The overall loss of value to the industry in scenario 3 is at least £334M – 89%. At this level of loss, it is expected that the majority of soft fruit growers would cease production. Individual crop losses range from £4.4M - 29% in blueberries, through to complete loss of value in strawberries, with raspberries reducing in value by £77M - 86%, blackberries by £7M - 86% and rhubarb by £17M - 66%. The loss of insect pest control would cause the largest reduction in farmgate value (£240M - 64%), strawberries being worst affected (£181M - 82%).

Chlorpyrifos is a vital component of many insecticide programmes and its loss would leave growers unable to control a wide range of pests e.g. raspberry beetle and blackberry leaf midge. This would reduce the farmgate value of the soft fruit crop group by £56M – 15%, with ***blackberry*** (£2M – 25%), ***blackcurrant*** (£3M – 21%) and ***raspberry*** (£18M – 20%) the worst affected crops, although the loss of value in ***strawberry*** would be higher at £33M – 15%.

Reduced disease control as a result of the combined loss of fungicides, especially botrytis control in ***strawberry*** and ***rhubarb*** (**iprodione**), will also reduce the value of the crop group

by £132M - 35%. The combined reduction in farmgate value to reduced weed control is £68M - 18%. Individually the yield impacts of a loss of insecticides would be enough to make production uneconomic, when combined with losses of fungicides and herbicides the impacts would be devastating.

In reality in this scenario the risk associated with the production of these crops would mean that the majority of soft growers would cease production, with knock on impacts on seasonal labour for picking and packing. Soft fruit production tends to be focused in particular regions of the UK, where soil and environmental conditions are suitable, predominantly in the South East, Eastern and West Midlands regions (Table 20) therefore job losses will have a high impact at a local level. Given that multiple crops will be affected, especially in the worst case scenario 3, there will be few alternative jobs for these workers to move in to. Many of these soft fruit growing areas within these regions have limited alternative job opportunities outside of agriculture, meaning that the wider impacts on the local communities will extend beyond the immediate job losses at the farm level.

Table 20 Percentage of soft fruit crops grown in the English regions

	Blackberry	Blackcurrant	Raspberry	Strawberry
South West	16		15	
South East	68	29	42	31
Eastern	9	35	21	13
East Midlands				10
West Midlands	7	23	18	32

Blackberry

There are approximately 210 ha of blackberry grown in the UK, with an estimated farmgate value of £8M.

Scenario 1 – Myclobutanil, tebuconazole, abamectin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £2.9M – 35% reduction in farmgate value.

The loss of **tebuconazole** (£0.8M – 10%) would substantially increase the risk of crop loss as a result of cane disease infection, cane spot, spur blight, cane blight and purple blotch. Control of downy mildew (dry berry), which effect's the foliage, shoot tips and the fruit of susceptible cultivars and most especially the protected blackberry crop, would also be impaired. In addition the control of downy mildew would become reliant on boscalid + pyraclostrobin and azoxystrobin, increasing the risk of resistance from occurring.

The loss of **abamectin** (£0.4M - 5%)**, thiacloprid** (£1.6M - 20%) and **tebuconazole** would have a serious impact upon blackberry production in the UK. As there are no alternatives for the control of adult and juvenile two spotted spider mite in the protected crop. Although alternatives to thiacloprid do exist for aphids, capsid, weevil and raspberry beetle control, the use of the majority of active substances is restricted to the outdoor crop.

Scenario 2 – Above plus propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £3.7M – 45% reduction in farmgate value.

Propyzamide (£0.4M – 5%) is the only residual herbicide with approval for use in established cane fruit crops providing pre and post emergence activity against the majority of grass species, also chickweed, annual nettle and knotgrass. An estimated 40% of the area of blackberries is treated with propyzamide each year. The loss of crop due to increased, and in some cases uncontrollable weed problems, as a result of the loss of this active is estimated to be 10%. The loss of propyzamide would mean that even where hand weeding was feasible effective post planting control of perennial grass weeds and creeping buttercup would become more or less impossible, resulting in many plantations with substantial weed crop competition for water, nutrients and light.

The use of **deltamethrin** (£0.4M – 5%) may increase in the future, as it is one of the active substances that have been identified as providing control of adult spotted winged drosophila (SWD). If SWD, as expected, becomes a serious problem of blackberry crops the loss of deltamethrin will reduce the options for SWD control potentially increasing its impact, especially in late summer-autumn cropping blackberries which are considered to be most vulnerable to this pest. .

Scenario 3 – Above plus fluazinam, fluazifop-p-butyl, glufosinate ammonium, lenacil, chlorpyrifos, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £7.2M – 86% reduction in farmgate value.

The loss of herbicides could be expected to move production further from soil grown into substrate, but this is a more expensive production system. The loss of **fluazifop-p-butyl** (£0.2M - 2%) would render selective control of grasses post emergence impossible. **Glufosinate ammonium** (£0.4M - 5%) is used in virtually all soil grown crops and also around pots or troughs of in substrate grown crops. The alternative, diquat is much less effective for grass control.

Currently there is a very limited range of residual herbicides for use in cane fruits **lenacil** (£0.4M - 5%) being particularly useful for the pre-emergence control of knotgrass, mallows and a range of cruciferous weeds.

The loss of **chlorpyrifos** (£2.1M - 25%) would be devastating because it is the final option for raspberry beetle and capsid and the only option for blackberry leaf midge control al be it in outdoor crops. Growers would face an impossible task and be unable to grow highly susceptible cultivars e.g. Lock Ness (the principle UK cultivar) which were not severely damaged-stunted by several generations of blackberry leaf midge. Ensuring that fresh and processed fruit was free of raspberry beetle would similarly be impossible.

Spinosad (£0.4M - 5%) is predominantly used for tortrix caterpillar control especially in protected crops where vapourer and other moth species are increasing in importance as pests. However its main value would be as a major defence against spotted wing drosophila.

The most serious impact would be the combined loss of insecticides which would leave the crop entirely vulnerable to losses caused by raspberry beetle, blackberry leaf midge, capsids, aphids, vine and clay coloured weevil, tortrix caterpillar and thrips. In addition in the case of the protected blackberry crop control of two spotted spider mite and blackberry mite would be impaired and there would be no options available to tackle spotted wing drosophila. Any one of these threats has the potential to render production uneconomic but taken together the result would certainly be disastrous for the crop. The effect of fungicide losses is almost as serious for cane disease and downy mildew control would further limit the profitability of the crop.

Conclusion

In scenario 1 would present challenges for the crop as regards insect and mite, cane disease and downy mildew control and cause loss of yield due to a lack of flexibility as regards control measures. As a result there would be the increased risk of failure to effectively control major pests and diseases especially cane diseases and raspberry beetle. Aphid control would also be more difficult.

In scenario 2, in addition to the challenges to disease and pest control in scenario 1, weeds and notably over winter germinated species, and particularly grasses, would become difficult to effectively control, requiring more hand weeding, thereby increasing the costs of production.

Scenario 3 would make it impossible to control the major pests affecting the crop i.e. raspberry beetle, blackberry leaf midge, adult vine and clay coloured weevils, tortrix caterpillars and leafhopper (the latter is the vector of the mycoplasma disease rubus stunt).

There is nil tolerance for the presence of damaged fruit, adult or larvae of raspberry beetle at the point of sale for fresh fruit or for fruit used for processing (IQF), so with the loss of thiacloprid, deltamethrin and chlorpyrifos many crops may be rejected just because of their contamination by this pest. If thrips and spotted winged drosophila became established as pests of the UK blackberry crop there would be no active substances available for their control.

Scenario 3 would cause substantial loss of crop production, most especially of protected blackberries where there is already a limited number of active substances available for pest and disease control. Control of perennial and annual grass weeds would become post emergence more of less impossible, resulting in an increase in the need to carry out hand weeding of many crops. In order to continue to grow blackberries in the UK it may become necessary to return the majority of the crop to outdoor production, so as to be able to render some pests and diseases either less of a problem or to be able to use the active substances remaining for their control. This would shorten the harvest period of the UK crop and render it prone to loss of crop due to weather damage.

Blackcurrant

There are approximately 2,470 ha of blackcurrant grown in the UK, with an estimated farmgate value of £12.3M.

Scenario 1 – Myclobutanil, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £0.2M – 2% reduction in farmgate value.

Loss of **thiacloprid** (£0.2M – 2%) would make currant scale control problematic. Currant scale occurs sporadically and, where affected plantations are untreated, increases in prevalence and severity in subsequent seasons. The pest reduces bush vigour due to sap loss and secondary infection by sooty mould, so the consequential loss can be expected to increase over time.

Scenario 2 – Above plus bupirimate, penconazole, metribuzin, propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £2.4M – 20% reduction in farmgate value.

The main impact of scenario 2 arises from the problems arising from the loss of effective residual herbicides **metribuzin** (£1.1M – 9%) and **propyzamide** (£1.1M – 9%). Weed control in bush fruit poses particular challenges: with neither contact herbicides nor cultivations being capable of providing in row control. These difficulties are particularly pronounced in young plantations, where the bushes themselves are smaller and less

competitive. The result is that the economic impact of the loss of effective residual herbicides can be expected to increase over time, as existing plantations reach the end of their economic lives, and replacement plantations need to be established.

Scenario 3 – Above plus chlorothalonil, fluazifop-p-butyl, glufosinate ammonium, lenacil, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £6.3M – 51% reduction in farmgate value.

Simultaneous loss of **thiacloprid, chlorpyrifos** (£2.6M - 21%)**, lambda-cyhalothrin** (£0.9M - 7%) and **spinosad** would leave producers without a broad-spectrum insecticide, and only able to control aphid, two spot spider mite (which are rarely a problem) and lepidopterous caterpillars. Producers would be unable to completely control winter moth, and completely unable to control sawfly and leaf midge.

No attempt has been made to quantify the effect of emergent pests (of which spotted wing drosophila one example), but history tells us that pest populations and spectra are not static, new challenges will arise in the future.

Conclusion

The major potential impact is from the loss of insecticides, where simultaneous loss of thiacloprid, chlorpyrifos, lambda-cyhalothrin and spinosad in scenario 3 would leave producers unable to control a range of common pests. Left untreated, populations of some pests increase over time, so the impact is likely to become greater in subsequent years.

Second most significant would be the effect of losses of residual herbicides, largely due to the fact that bush fruit performs poorly in the face of weed competition, coupled with the situation that so few approvals remain for effective residual herbicides. Even today, commercial growers occasionally fail to achieve satisfactory weed control with the materials available – reduce the options further and yield loss is inevitable.

Numerous fungicide options are available, and the chief danger of reducing the range of materials available is overuse of those that remain, leading to the development of resistance, but in the short term the impact on yields would be negligible.

The likely yield loss arising consequent to Scenarios 2 and 3 are **very** significant. This level of loss would be extremely challenging for the UK blackcurrant crop and with farm-gate values unlikely to compensate growers, would likely result in a significant reduction in area grown, loss of jobs in the crop and an increased reliance on extra-EC imports.

Blueberry

There are approximately 340 ha of blueberries grown in the UK, with an estimated farmgate value of £15M.

Scenario 1 – Fenbuconazole, amitrole, thiacloprid,

The impact of the loss of active substances in scenario 1 is estimated to be a £1.6M – 11% reduction in farmgate value.

Under scenario 1 the only serious impact would arise from the loss of **thiacloprid**. However, thiacloprid is one of the products currently regarded as essential for protected blueberry production. Although registered under an extension of use approval, for the control of light brown apple moth (LBAM) it has a strong side effect on vine weevil adults, aphids and a useful effect on blueberry midge.

Scenario 2 – Above plus penconazole, propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £1.6M – 11% reduction in farmgate value.

The loss of **propyzamide** could be tolerated if the current range of pre-emergence and post emergence herbicides is otherwise maintained. Should diquat or glufosinate-ammonium be withdrawn or the number of applications be limited the impact of losing propyzamide would be substantially increased.

Scenario 3 – Above plus fluazifop-p-butyl, glufosinate ammonium, lambda-cyhalothrin, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £4.4M – 29% reduction in farmgate value.

The loss of **glufosinate ammonium** (leaves growers with limited options for contact weed control. In addition to hand weeding there are other potentially useful options these include; hot foam and acetic/citric acid products. However the annual cost and efficacy of these options has not been properly evaluated for blueberries in the UK. Most growers use mulches (e.g. polythene/Mypex types and wood waste/bark) but these do not eliminate the use of post emergence herbicides.

Although both **thiacloprid** and **lambda-cyhalothrin** (£2.8M – 19%) are registered for specific pests, the loss of two major, broad spectrum insecticides would have a serious wider impact on blueberry pest control unless effective alternatives were made available. While the crop loss estimates have been based on the likely increase in root/crown injury caused by vine weevil larvae they may underestimate losses resulting from aphid and caterpillar damage. SWD has not caused significant crop loss at the time of writing, but the

population of this pest is expected to increase quickly. Average crop losses at North American blueberry farms have reached 40% with some growers reporting 80% (Fountain 2012[3]). After subtracting losses caused by vine weevil, to avoid double counting, a 40% further reduction in crop would effectively double the estimated economic loss figure (£4.4M + £4.4M = £8.8M) with some farms unable to grow a commercially viable blueberry crop.

Conclusion

While still relatively small, the UK blueberry crop has expanded rapidly over recent years. Home grown production increased by approximately 50% between 2011 and 2012. Sales of blueberries now rival that of raspberries, but UK production accounts for only around 20% of summer/autumn sales and almost none during other periods. Blueberries represent a clear opportunity for increased substitution of UK produce for imports. One of the most important factors limiting the expansion of UK production is that of production costs, the most important component of that being 'labour'. Growers cannot afford to increase hand weeding costs, hand drenching (for vine weevil larvae) or sorting costs (for caterpillar, sooty mould and other contaminants) when UK labour costs are already considerably higher than our principal competitors in Poland and Spain. At the very least the crop would need time and funds at least equivalent to the losses forecast to develop effective technical alternatives to the insecticide and herbicide active substances listed in this report.

The main direct loss of production (£4.4M - rising to £8.8M) arising from the above scenarios would be the impact of insect pests should **thiacloprid** and **lambda-cyhalothrin** be withdrawn.

Raspberry

There are approximately 1,620 ha of raspberries grown in the UK, with an estimated farmgate value of £90.4M.

Scenario 1 – Iprodione, myclobutanil, tebuconazole, abamectin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £32M – 35% reduction in farmgate value.

Myclobutanil (£3M - 3%) is particularly useful for powdery mildew and raspberry rust control in autumn and double i.e. spring and autumn cropping primocane raspberry crops where the growing conditions are often very conducive for infection by these diseases and the long harvest periods can restrict the use of other active substances ingredients e.g. azoxystrobin, tebuconazole. Approximately 66% of the raspberry area is currently grown under protection.

The greatest impact of the loss of **tebuconazole** (£9M - 10%) would be as an active for cane disease and early season powdery mildew control. The protection of crops beneath polythene clad tunnels for increasingly long periods has created ideal climatic conditions for cane blight development on floricane. The majority of commercial cultivars of summer and double cropped primocane cultivars can become infected by this disease, but most susceptible are Glen Ample, Octavia and Tulameen. Losses of 20-60% of floricane and crop as a result of cane blight or midge blight can occur.

A**bamectin** (£6M - 7%) is the only acaricide with approval for use in raspberry which provides any control of raspberry leaf and bud mite and even then control is not high and considerable crop loss occurs as the result of the Raspberry Leaf Blotch Virus they have vectored.

Thiacloprid (£14M - 15%) is used widely in cane fruit crops in the UK for raspberry beetle, capsid, aphid, adult weevil control i.e. vine weevil, clay coloured weevil, *Phyllobious pomaceous* found feeding on the foliage and or fruit laterals and flowers of cane fruit crops. At least 70% of the area UK cane fruit crops are currently treated annually with thiacloprid.

The loss of abamectin, thiacloprid and tebuconazole would have a serious impact upon raspberry production in the UK. As there are no alternatives for the control of adult and juvenile two spotted spider mite in protected raspberry crops. Although alternatives to thiacloprid do exist for aphids, capsid, weevil and beetle control, thiacloprid is particularly valuable because of its efficacy, low impact upon IPM and short harvest interval. Its loss will lead to the use of far less environmentally friendly options for the control of raspberry beetle and capsid. Tebuconazole loss would substantially increase the risk of crop loss as a result of cane disease infection and notably as a result of cane blight. Control of powdery mildew and raspberry rust would also prove to be more difficult especially where levels of over wintered infection are high at the onset of the growing season.

Scenario 2 – Above plus bupirimate, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £41M – 46% reduction in farmgate value.

The loss of **bupirimate** (£2M - 2%) and **tebuconazole** could lead to difficulties in effectively controlling powdery mildew in plantations of highly susceptible varieties such as Glen Ample or Glen Fyne. Some control of powdery mildew can be expected from the use of boscalid + pyraclostrobin, but would not be as effective as bupirimate in eradicating existing mildew infection of fruit, foliage or shoot tips.

Propyzamide (£4M – 4%) is a residual benzamide with pre and post emergence activity against a wide range of annual and some perennial broad leaved weeds, and many grass weeds.

An estimated 41% of the area of raspberries is treated with propyzamide each year. The loss of crop due to increased and in some cases uncontrollable weed problems as a result of the loss of this active is estimated to be 10%. Additional costs would also be incurred as hand weeding would be necessary in order to provide at least some control of some weeds notably perennial grasses.

It is expected that the use of **deltamethrin** (£5M – 5%) will increase as it is one of the active substances that has been identified as providing control of adult spotted winged drosophila (SWD).

Scenario 3 – Above plus fluazinam, fluazifop-p-butyl, glufosinate ammonium, lenacil, chlorpyrifos, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £77M – 86% reduction in farmgate value.

A high percentage of in soil and in substrate crops are routinely treated with **fluazinam** (£9M – 10%) applied as a drench or via trickle irrigation to control-supress *Phytophthora rubi* (raspberry root rot control). Unfortunately the majority of commercial raspberry cultivars are currently susceptible to infection. Cultivars with reliable resistance or good tolerance to infection that are also suitable for fresh fruit sales are proving difficult to breed. So for the foreseeable future the use of fungicides for controlling this disease even for in pot (in substrate) grown crops. Dimethomorph is also used for raspberry root rot control along with metalaxyl-M - however use of the latter is confined to outdoor crops and only one application of the former is permitted/year on either outdoor or protected crops.

The loss of **fluazifop-p-butyl** (£2M – 2%) would render selective control of grasses post emergence impossible.

Glufosinate-ammonium (£3M – 4%) is used in virtually all soil grown crops and also around pots or troughs of in substrate grown crops i.e. around 35% of the national area. Applied to remove or to supress many annual and perennial grass and broad-leaved weeds. The alternative, diquat is much less effective for grass control. The reduction in farmgate value is estimated at 10%, although the main impact will be increased costs (not captured here) i.e. the need to carry out strimming or hand weeding along edges of rows or hand weeding of centre of rows to remove weeds.

Lenacil (£1M – 1%) is used for the pre-emergence control of knotgrass, mallows and a range of cruciferous weeds. It also offers pre-emergence control of annual meadow grass

germinating in the spring months, orache, fat hen and redshank, which can be problem weeds in establishment and other early years of an in-soil plantations life. Seventy seven per cent of this crop is grown in soil.

The loss of **chlorpyrifos** (£18M – 20%) would be devastating because it is the only effective treatment authorised for raspberry cane midge adult and larval control in summer and primocane fruiting raspberry. Furthermore the use of chlorpyrifos is important for the control of blackberry leaf midge a common and often serious pest of both autumn and spring-early summer and autumn (double cropping) primocane fruiting raspberry crops. The combined effect of losing **thiacloprid, lambda-cyhalothrin, deltamethrin**, and **chlorpyrifos** would leave growers with no options for control of capsids, raspberry beetle, strawberry blossom weevil, raspberry cane midge (adults and larvae), blackberry leaf midge (adults and larvae), small raspberry sawfly and substantially reduced options for aphid control. The loss of **spinosad** (£3M – 3%) and **lambda-cyhalothrin** in addition to that of chlorpyrifos and deltamethrin would leave no options to combat spotted wing drosophila (SWD) which could in itself destroy the crop.

Conclusion

The first scenario would present some challenges for the crop as regards insect and mite, cane disease and powdery mildew control and would lead to some loss of yield due to a lack of flexibility as regards control measures and as a result of the increased risk of failure to effectively control major pests and diseases especially cane blight and raspberry beetle. It is estimated that losses from this scenario would amount to £32M - 35% of production. This would knock the profitability of the crop, but it would probably adapt and cope.

The second scenario presents similar challenges for insect and mite control, but in addition control of powdery mildew would be much more difficult due to a reduction of the active substances that could be used control this disease in outdoor crops.

In addition perennial and annual weed control especially of grasses and overwinter germinated weeds such as cleaver would be difficult if not impossible in the case of perennial grasses e.g. couch with the loss of propyzamide. This would result in shorter plantation lives, increased costs for hand weeding and a reduction in berry size and yield due to weed competition with the crop.

It is estimated that losses from this scenario would amount to £41m - 46% of production when taking into account herbicide losses as well. It is unlikely the crop could cope with this level of reduction unless some mitigation was possible - for example by the development of varieties less susceptible to powdery mildew that had market acceptability.

In the third scenario it would be impossible to control the major pests affecting the crop i.e. raspberry beetle, raspberry cane midge, blackberry leaf midge, adult vine and clay coloured weevils. With the additional problem of a nil tolerance for contamination of crop at point of fresh fruit sale or for fruit used for processing using IQF. Even crops where reasonable control of raspberry beetle was achieved may be rejected due to pest contamination. If thrips and spotted winged drosophila became established as pests of the UK raspberry crop there would be no active substances available for their control.

Scenario 3 would lead to a £68M or 75% loss of crop production, making the crop uneconomic and unlikely to be able to continue on the current scale with consequent loss of jobs and an increased reliance on imports.

Rhubarb

There are approximately 430 ha of rhubarb grown in the UK, with an estimated farmgate value of £26M.

Scenario 1 – Iprodione, mancozeb

The impact of the loss of active substances in scenario 1 is estimated to be a £13M – 50% reduction in farmgate value.

Iprodione (£5M - 19%) is a key treatment for black top in rhubarb and the loss will mean extra labour and loss of potential crop. Increasingly the crop is forced or blanched in the field using black polythene and loss of botrytis control is a threat to this crop.

Mancozeb (£8M - 31%) is used in combination with metalaxyl-M for downy mildew control. Downy mildew is an increasing problem to growers and will stop harvesting by marking the sticks, it also causes a loss of leaf area. The active metalaxyl–M would be the greater loss as it is not currently approved alone or in combination with any other product. Possibly transfer the EAMU to another Metalaxyl product minus the mancozeb would reduce the impacts.

Scenario 2 – Above plus difenoconazole, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £17M – 66% reduction in farmgate value.

Difenoconazole is a useful wide spectrum fungicide and will help in field and nursery production to control diseases like ramularia and other leaf spots. Loss of **propyzamide** (£3M – 10%) as a winter applied herbicide, with activity against cleavers and grasses will be a blow for producers. The crop is already difficult to keep weed free and growers are struggling with new weeds like Himalayan Balsam, on top of the existing problems. Several

active substances are required so that balanced programmes can be developed providing scope for avoiding the build-up of resistant weeds. **Deltamethrin** (£1M – 5%) is useful to control flea beetle damage that occurs most years and Rosy Rustic moth that is a damaging pest in established areas notably Yorkshire.

Scenario 3 – Above plus thiram

The impact of the loss of active substances in scenario 3 is estimated to be a £17M – 66% reduction in farmgate value.

There will be little impact of losing **thiram** as at present it only has an EAMU as a seed treatment and very few growers grow the crop from seed.

Conclusion

Rhubarb is enjoying a revival in both the forced and outdoor green pulled or garden rhubarb, but the number of active substances available has not kept up with the needs of the crop. The economic losses discussed above, particularly **iprodione** for forced production and **propyzamide** for field, have the potential to make the crop less competitive compared to imports and in overall terms with profit margin already low. The proposed losses would be expected to have the greatest impact in the forced crop, which is very reliant upon effective botrytis control. The forced crop is a useful source of employment over winter providing work at a time when few other crops require labour. The losses could result in the crop having difficulties supplying regular orders of the more profitable forced rhubarb to UK supermarkets, potentially losing business and reducing the overall viability of rhubarb as a crop to these growers.

The very few active substances available for this crop mean that there is little flexibility for further reductions in available fungicide, herbicide and insecticide active substances. The developing “Grow your own” movement supplied largely by ornamental growers is increasing in value and the proposed losses of several active substances with seemingly low potential for financial impact on the crop as a whole would impact this crop disproportionately. There is renewed interest in rhubarb mainly thanks to the promotional activity within the rhubarb triangle in Yorkshire, plus TV Chefs advocating the use of this crop. Larger area growers have taken up the crop as supermarkets are interested in as long a season as possible. The loss of any active will be difficult for the crop and may well inhibit the full potential as a UK crop being realised.

Strawberry

There are approximately 4,650 ha of strawberry grown in the UK, with an estimated farmgate value of £222M.

Scenario 1 – Iprodione, myclobutanil, amitrole, abamectin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £98M – 44% reduction in farmgate value.

The loss of the very widely used fungicides **iprodione** (£17M – 8%) and **myclobutanil** (£11M – 5%) will have a serious impact on control of Botrytis fruit rot and powdery mildew. Although alternatives exist the short harvest interval and unique mode of action of iprodione is extremely valuable and the effectiveness and availability of multiple applications for myclobutanil also make it important to the crop. Reduction in farmgate value following withdrawal of Iprodione is estimated at 5-10%, with losses following withdrawal of myclobutanil closer to 5%.

The loss of widely used insecticides **abamectin** (£34M – 13%) and **thiacloprid** (£58M – 19%) is the most serious impact of this scenario. Although alternatives exist for control of two spotted spider mite, tarsonemid mite, blossom weevil, aphids and capsids these products are particularly valuable because they are very effective and have relatively short harvest intervals and, because of limited persistence, can be integrated relatively easily into IPM programmes including biological control agents. This resulting loss of flexibility will inevitably lead to losses from potentially all of these pests. The loss of abamectin would therefore lead to a considerable loss of flexibility in mite and thrips control. For this reason yield losses range from 10-15%. The yield losses following withdrawal of thiacloprid range from 10-27%, due to reduced capsid control, mid-season blossom weevil control and some loss of vine weevil adult control.

Scenario 2 – Above plus bupirimate, penconazole, propyzamide, deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £184M – 83% reduction in farmgate value.

The further losses of fungicides would impact on disease control with the removal of **bupirimate** (£28M - 13%) and **penconazole** (£28M - 13%) in addition to the loss of myclobutanil, very limited options remaining for powdery mildew control, which can be particularly devastating, especially on 60 day crops and everbearers. Market requirements limit the options for using resistant varieties at present.

As with scenario 1, the loss of insecticides remains the most serious impact with the further loss of **deltamethrin** (£23M - 11%) having an effect on SWD control. Deltamethrin has an important role in spotted wing drosophila (SWD) control, consequently resulting crop losses following its loss are difficult to calculate depending on the likely extend of SWD infestation, but could be estimated to range from 1% to 20%.

Scenario 3 – Above plus fosetyl ammonium, thiram, chlorothalonil, fluazifop-p-butyl, glufosinate ammonium, lenacil, S-metolachlor, chlorpyrifos, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £222M – 100% reduction in farmgate value.

The most serious impact in scenario 3 would be the combined loss of insecticides, which would leave the crop entirely vulnerable to losses caused by capsids, blossom weevil and for soil grown crops, vine weevil. In addition there would be no options available to tackle the threat of spotted wing drosophila. Any one of these threats has the potential to render production uneconomic, but taken together the result would certainly be disastrous for the crop. The effect of fungicide losses is almost as serious for powdery mildew and Phytophthora diseases and would further limit the profitability of the crop. The loss of herbicides and vine weevil control would tend to move production further from soil grown into substrate, but this is a more expensive production system and with the problems caused by lack of disease and pest controls it is difficult to see a viable crop remaining, even on a small scale.

Conclusion

The first scenario would present a very serious challenge for the crop in insect and mite control and to some extent in powdery mildew and botrytis fruit rot control. It would lead to a considerable loss of yield due to a lack of flexibility in control measures with an increased number of failures of control. It is estimated that losses from this scenario would amount to between £68M and £129M or 30% - 58% of production. For a crop that is currently at very marginal profitability levels of between minus 5% to plus 5% even the lower estimate of crop loss would be more than enough to make the crop unprofitable.

The second scenario presents even more of a challenge for insect, mite and SWD control and in addition control of powdery mildew would be much more difficult due to a majority of control measures being withdrawn causing considerable crop losses for some main crop, 60 day and everbearer crops. It is estimated that losses from this scenario would amount to between £132M and £235M or 60% - 100% of production when taking into account herbicide losses as well. The crop would be unable to cope with this level of loss.

The third scenario would be impossible to cope with due, in particular, to the withdrawal of the majority of insecticides leaving no control measures available for capsids and blossom weevil and vine weevil in soil grown crops, which currently constitute 69% of the area. In addition the crop would have no control measures available for spotted wing drosophila, a factor which could in itself destroy the crop. It is estimated the combined effect of these losses would result in over 100% of crop losses, more than the total farmgate vale of

£221M. Even the first scenario level of loss would be devastating for the UK strawberry crop, production would be hopelessly uneconomic, with a consequent loss of jobs in the crop and an increased reliance on EU and extra-EU imports. It is worth noting no allowance has been made for increased costs (for example hand labour, more frequent application of less effective products) resulting from the loss of active substances and these costs would be considerable. Furthermore, the costings are based on farmgate vales which are considerably less than retail value.

Tree fruit

The total farmgate value of the tree fruit crop group (cider apples, pome fruit – apples and pears - and stone fruit- cherries and plums) is estimated at £197M per year (Table 21), with approximately 19,150 ha of tree fruit crops grown each year. The largest crop in terms of area grown and value is the pome fruit crop at £144M per year, with the cider fruit accounting for a further £30M.

Table 21 Summary of economic losses £M - based on yield loss only, in tree fruit crops across the three scenarios of endocrine disrupting pesticide loss

		Cider fruit	Pome fruit - call apples and pears	Stone fruit	Tree fruit
Crop area	**(ha)**	**7,200**	**10,203**	**1,744**	**19,147**
Production	**(t)**	**250,000**	**287,326**	**9,966**	**547,292**
Farmgate value	**(£M)**	**£30**	**£144**	**£24**	**£197**
Scenario 1	Fungicides	£2	£9	£1	**£11**
Scenario 1	Herbicides	£0	£0	£0	**£0**
Scenario 1	Insecticides	£5	£29	£1	**£35**
Scenario 1	All pesticides	£7	£37	£2	**£46**
Scenario 2	Fungicides	£3	£30	£1	**£34**
Scenario 2	Herbicides	£0	£0	£0	**£0**
Scenario 2	Insecticides	£5	£29	£4	**£37**
Scenario 2	All pesticides	£8	£58	£5	**£71**
Scenario 3	Fungicides	£3	£30	£1	**£34**
Scenario 3	Herbicides	£2	£7	£2	**£11**
Scenario 3	Insecticides	£9	£50	£5	**£64**
Scenario 3	All pesticides	£14	£87	£8	£109

Scenario 1 – Iprodione, mancozeb, myclobutanil, tebuconazole, amitrole, abamectin, thiacloprid

The overall impact of lost yield to the tree fruit sector of losing the active substances in scenario 1 is £46M - 23% of the value of the crop group. With many growers expected to cease production due to unfavourable returns.

The most significant loss in scenario 1 is the loss of **thiacloprid** which would reduce the value of the crop group by up to £27M - 14%. Its loss would seriously compromise the control of apple blossom weevil, apple fruit rhynchites weevil, apple sawfly and mussel and nut scale in ***cider fruit*** and ***pome fruit*** and black cherry aphid and plum aphid control in ***stone fruit***.

The loss of **myclobutanil** would reduce the value of the crop group by up to £10M - 5%, as a result of reduced powdery mildew control in ***cider fruit*** and ***pome fruit*** and reduced plum rust control in ***stone fruit***.

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, metribuzin, propyzamide, deltamethrin

The overall impact of lost yield to the tree fruit sector of losing the active substances in scenario 2 is up to £71M - 36% of the value of the crop group.

The most significant additional loss in this scenario is the loss of **difenoconazole** (£14M - 7%) causing a further reduction in the ability to control powdery mildew, especially in ***pome fruit***. The loss of **bupirimate** (£14M – 7%) and **penconazole** (£17M – 9%) would further reduce the ability to control powdery mildew in tree fruit.

Scenario 3 – Above plus fluazinam, fosetyl aluminium, fluazifop-P-butyl, glufosinate ammonium, lenacil, chlorpyrifos, lambda-cyhalothrin, spinosad

The overall impact of lost yield to the tree fruit sector of losing the active substances in scenario 3 is a reduction in farmgate value £109M - 55% for the crop group. The loss of herbicides in this scenario is a serious concern as the alternative control options are costly and would result in further reductions in the profitability of these crops that are not captured in the yield loss figures. This level of losses would be unsustainable and most conventional growers would cease production.

Cider Fruit

There are approximately 7,200 ha of cider fruit grown in the UK, with an estimated farmgate value of £30M.

Scenario 1 – Mancozeb, myclobutanil, abamectin, fenoxycarb, thiacloprid,

The impact of the loss of active substances in scenario 1 is estimated to be up to a £7M – 22% reduction in farmgate value.

Loss of **myclobutanil** (£1.5M – 5%) would seriously reduce the efficacy of powdery mildew control programs and lead to increased use of the remaining active substances potentially resulting in the development of resistance/sensitivity changes. In years where the weather conditions are favourable for powdery mildew yield losses could exceed 10%.

The loss of **thiacloprid** (£4.5M – 15%) would seriously compromise the control of apple blossom weevil, apple fruit rhynchites weevil, apple sawfly and mussel and nut scale as the timings for control of these are different and we have only two applications. At present if all types are present then the program consists of thiacloprid and chlorpyrifos, losing one of these active substances would clearly pose a significant problem.

Loss of **abamectin** would make the control of scarlet flat mite virtually impossible resulting in a reduction in farmgate value of up to £2M - 5%.

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be up to a £8M – 27% reduction in farmgate value.

If **bupirimate**, **penconazole** and **myclobutanil** were lost then powdery mildew control would not be possible and yield losses could easily exceed £3M - 10%.

Scenario 3 – Above plus thiram, 2,4-D, fluazifop-P-butyl, glufosinate ammonium, chlorpyrifos, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be up to a £14M – 47% reduction in farmgate value.

Loss of **glufosinate ammonium** (£1.5M – 5%) would make summer weed control extremely difficult resulting in a reduction in yield and in the quality and quantity of fruit bud for the following season due to increased competition for nutrients. However the main impact would be on the cost of control as alternative methods of weed control, mowing / mulching are high cost in comparison. This increased cost of production is not captured in these figures.

Loss of **chlorpyrifos** (£4.5M – 15%) along with thiacloprid would make control of weevils, sawfly and mussel scale impossible resulting in a reduction in farmgate value of the crop in excess of £9M -30%.

Conclusion

All 3 scenarios would present major problems in pest and disease control, scenario 3 would also present real problems for successful summer weed control. Scenario 1 with the loss of **myclobutanil** would make powdery mildew control less successful, but scenario 2 with the additional loss of **bupirimate** and **penconazole** would mean that powdery mildew control would be severely compromised and would put extra pressure on the remaining active substances, several of which are strobilurins which need to be carefully managed from the resistance point of view. The loss of **thiacloprid** in scenario 1 would make the control of weevils, sawfly and mussel scale very challenging, but in Scenario 3 with the additional loss of **chlorpyrifos**, control would not be possible and consequent losses would be in excess of 30%.

Pome Fruit

There are approximately 10,200 ha of pome fruit grown in the UK, with an estimated farmgate value of £144M.

Scenario 1 – Mancozeb, myclobutanil, tebuconazole, abamectin, fenoxycarb, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be up to a £37M – 26% reduction in farmgate value.

Loss of **mancozeb** would result in <1% yield loss, however the loss of this mode of action would mean that there is an increased risk of resistance building to other active substances, which could result in further yield losses in the future.

Loss of **myclobutanil** (£7M – 5%) would seriously reduce the efficacy of powdery mildew control programs and lead to increased use of the remaining active substances potentially resulting in the development of resistance/sensitivity changes. In years where the weather conditions are favourable for powdery mildew yield losses could exceed 10%.

The removal of **tebuconazole** (£1M - 1%) would leave growers with no active substances for the control of apple canker, this would make it very difficult for growers to continue to grow canker susceptible cultivars in some parts of the UK especially the South West and West Midlands.

The loss of **thiacloprid** (£22M - 15%) would seriously compromise the control of apple blossom weevil, pear bud weevil, apple fruit rhynchites weevil, apple sawfly and mussel scale. A programme of sprays using thiacloprid and chlorpyrifos is currently used to control these pests losing one of these active substances would clearly pose a significant problem.

If **fenoxycarb** (£7M - 5%) were to be lost then there would be an over reliance on methoxyfenozide, chlorantraniliprole, spinosad and granulososis virus for the control of caterpillars. The use of chlorpyrifos for control of caterpillars in apple and pear orchards could also be expected to increase. In addition in seasons where there is a partial second generation of codling, growers may run out of options in August and September. In this case crop losses could exceed 10%.

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be up to a £58M – 41% reduction in farmgate value.

Loss of two further triazoles **difenoconazole** and **penconazole** would seriously reduce the efficacy of mildew control programs and lead to increased use of the remaining active substances potentially resulting in the development of resistance/sensitivity changes. If **penconazole** (£4M – 3%), **bupirimate** (£4M – 3%) and **myclobutanil** were lost then mildew control would be very difficult and yield losses could easily exceed 10%. Loss of **difenoconazole**, one of the few curative scab products available, would result in some crop losses typically £14M – 10%, in high disease pressure seasons this could rise to £28M - 20% and put increased pressure on the remaining active substances which have curative activity.

Deltamethrin is not currently widely used, however in the absence of thiacloprid in scenario 1 usage could be expected to increase.

Scenario 3 – Above plus thiram, 2,4-D, fluazifop-p-butyl, glufosinate ammonium, chlorpyrifos, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be up to a £87M – 61% reduction in farmgate value.

Loss of **glufosinate ammonium** (£7M – 5% in first year) would make summer weed control extremely difficult resulting in a reduction in yield and in the quality and quantity of fruit bud for the following season due to increased competition for nutrients. However, poor control of weeds, especially during the establishment of a new orchard can have a cumulative impact year on year with losses expected to rise in 5 years as establishment of new orchards is compromised. There would need to be changes in practice to manage the vegetation under trees, changing the plants grown underneath, and using mowing and mulching to manage them. This would have impacts on cost of production that are not captured in this report.

Loss of **chlorpyrifos** (£22M – 15%) along with thiacloprid would make control of weevils, sawfly and mussel scale impossible resulting in crop losses in excess of 30%.

Conclusion

All three scenarios would present major problems in pest and disease control, scenario 3 would also present real problems for successful summer weed control. Scenario 1 with the loss of **myclobutanil** would make mildew control less successful, but scenario 2 with the additional loss of **penconazole** and **bupirimate** would mean that mildew control would be severely compromised and would put extra pressure on the remaining active substances, several of which are strobilurins which need to be carefully managed from the resistance point of view. The loss of **thiacloprid** in scenario 1 would make the control of weevils, sawfly and mussel scale very challenging, but in Scenario 3 with the additional loss of **chlorpyrifos,** control would not be possible and consequent losses would be in excess of 30%.

Stone Fruit

There are approximately 1,740 ha of stone fruit grown in the UK, with an estimated farmgate value of £24M.

Scenario 1 – Myclobutanil, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £2M – 10% reduction in farmgate value.

Loss of **myclobutanil** (£1M – 5%) would lead to challenges in controlling plum rust, especially in Victoria plums. In bad rust years losses could exceed 35% in the absence of this fungicide, reducing farm gate value by £8M.

Thiacloprid (£1M – 5%) is approved for the control of black cherry aphid and plum aphid and there are few effective alternatives with approval, so its loss would not only make control difficult but would put additional pressure on the remaining active substances.

Scenario 2 – Above plus propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £5M – 20% reduction in farmgate value.

Loss of **deltamethrin** would leave only **lambda cyhalothrin** for the control of SWD and it is likely that with only one active available, resistance would develop. This is a new pest in the UK, but it has caused severe crop losses where it occurs overseas. Losses in the UK especially of sweet cherry could be in excess of 50% in some seasons, but typical impact at present levels would be less (£2M - 10%).

Scenario 3 – Above plus glufosinate ammonium, chlorpyrifos, lambda-cyhalothrin, spinosad

The impact of the loss of active substances in scenario 3 is estimated to be a £8M – 35% reduction in farmgate value.

The loss of **glufosinate ammonium** would mean that after white bud (the cut off point for glyphosate) weed control in cherry would be extremely difficult, less so in plum which has other herbicide approvals. However, in both cases there would be over-reliance on the remaining active substances and weed control would be poor. This would reduce yield and also the potential for cropping next year, typical reduction in value is estimated at £2M -10% rising to £7M – 30% in bad weed years, as with the pome fruit the main impact of a loss of herbicides control would be a significant increase in the cost of weed control with growers having to switch to more labour intensive methods, which is not captured in the figures above.

Although there are other active substances that can be used for plum fruit moth control i.e. diflubenuron e.g. Dimilin Flo *& bacillus thuringiensis* (Dipel DF) the loss of **chlorpyrifos** (£1M – 5%) on plum would make the control of plum fruit moth and other caterpillars e.g. winter moth very difficult.

The loss of **spinosad**, **lambda cyhalothrin** (along with deltamethrin) would make the control of SWD, if it becomes established, impossible resulting in yield losses of up to 50%. Figures for these losses have not been included in the overall calculation.

Conclusion

The loss of the insecticides would have the largest impact on stone fruit production with decreased ability to control aphids, caterpillars and the non-native SWD if it becomes established. These pests have the potential to cause serious damage to the crop and if left uncontrolled, especially SWD could lead to devastating losses in the crop, with producers ceasing production.

Ornamental horticulture

The total farmgate value of the ornamental horticulture sector (bedding and pot plants, bulbs and cut flowers and hardy nursery stock) is estimated at £1236M per year (Table 22), with approximately 5000 ha of ornamental crops grown each year. The largest crop in terms of area grown and value is the hardy nursery stock crop at £1000M per year, with the bedding and pot plants accounting for a further £206M. The figures presented for bedding and pot plants and HNS are worst case scenario figures and therefore the actual impacts could be less as the industry adapts to production with fewer active substances available,

however cost of production would increase in this situation and those figures are not captured.

Table 22 Summary of economic losses £M - based on yield loss only, in ornamental crops across the three scenarios of endocrine disrupting pesticide loss

Crop area (ha)		Bedding and pot plants	Bulbs and Outdoor Flowers,	Hardy nursery ornamental stock	Ornamental horticulture
Production (t)				5,000	5,000
Farmgate value	(£M)	£206	£37	£1,000	£1,243
Scenario 1	Fungicides	£24	£4	£136	**£164**
Scenario 1	Herbicides	£0	£0	£1	**£1**
Scenario 1	Insecticides	£6	£0	£146	**£152**
Scenario 1	All pesticides	£30	£5	£283	**£317**
Scenario 2	Fungicides	£29	£6	£163	**£199**
Scenario 2	Herbicides	£0	£0	£2	**£2**
Scenario 2	Insecticides	£10	£0	£152	**£162**
Scenario 2	All pesticides	£40	£6	£317	**£364**
Scenario 3	Fungicides	£36	£13	£208	**£257**
Scenario 3	Herbicides	£8	£0	£86	**£94**
Scenario 3	Insecticides	£19	£1	£191	**£211**
Scenario 3	All pesticides	£63	£14	£485	£562

Scenario 1 – Cyproconazole, epoxiconazole, mancozeb, myclobutanil, iprodione, prochloraz, tebuconazole, linuron, abamectin, cypermethrin, fenoxycarb, thiacloprid

The overall impact of lost yield to the ornamental horticulture sector of losing the active substances in scenario 1 is £317M - 26% of the value of the sector.

The loss of fungicides would reduce the farmgate value of the ornamental horticulture sector by £164M – 13%. This is predominantly as a result of the loss of **prochloraz** (£75M – 6%) for powdery mildew control and **iprodione** (£30M - 2%) for botrytis control.

The loss of insecticides would reduce the farmgate value of the sector by £152M – 12%, predominantly as a result of the loss of mite control following the withdrawal of **abamectin** (£110M – 9%).

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, propiconazole, thiophanate-methyl, metribuzin, propyzamide, deltamethrin, spiromesifen

The overall impact of lost yield to the ornamental horticulture sector of losing the active substances in scenario 2 is £364M - 29% of the value of the sector.

The loss of fungicides would reduce the farmgate value of the ornamental horticulture sector by £199M – 16%, following the additional loss of **bupirimate** (£24M – 2%) further reducing powdery mildew control.

The loss of insecticides would reduce the farmgate value of the sector by £162M – 13%, predominantly as a result of the loss of mite control following the withdrawal of **spiromesifen** (£5M – <1%) and general pest control as a result of the loss of **deltamethrin** (£5M – <1%).

Scenario 3 – Above plus chlorothalonil, cymoxanil, fosetyl-aluminium, mandipropamid, propiconazole, prothioconazole, thiram, 2,4-D, chlorpropham, dimethenamid-p, ethofumesate, fluazifop-p-butyl, glufosinate-ammonium, lenacil, s-metolachlor, tepraloxydim, terbuthylazine, chlorpyrifos, dimethoate, lambda-cyhalothrin, spinosad, spirotetramat, lambda-cyhalothrin, spinosad, spirotetramat.

The overall impact of lost yield to the ornamental horticulture sector of losing the active substances in scenario 3 is £566M - 46% of the farmgate value of the sector.

The loss of fungicides would reduce the farmgate value of the ornamental horticulture sector by up to £257M – 21%, with the main additional loss from **fosetyl aluminium** (£40M – 3%).

The loss of insecticides would reduce the farmgate value of the sector by up to £210M – 17%, the main additional loss would be as a result of losing **chlorpyrifos** (£24M - 2%) and **spinosad** (£13M - 1%).

The loss of herbicides would reduce the farmgate value of the sector by £94M – 8%, mostly as a result of the loss of **glufosinate ammonium** (£56M - 5%) and **lenacil** (£24M – 2%).

The ornamental horticulture sector relies on a ‘perfect blemish free product, with any sign of pest or damage resulting in loss of sales. There are already a restricted number of active substances available to the crop and any additional losses of active substances increases the risk of damage and resultant sales losses. The industry is already producing plants with very tight sales margins and as a result any increase in cost of production, or reductions in the proportion of marketable crop will have severe implications for the crop. Where control cannot be achieved some growers are expected to cease production.

Bedding and pot plants

Bedding and pot plants have an estimated farmgate value of £206M.

Scenario 1 – iprodione, mancozeb, myclobutanil, prochloraz, abamectin, cypermethrin, thiacloprid,

The impact of the loss of active substances in scenario 1 is estimated to be a £30M – 15% reduction in farmgate value.

Mancozeb (£12M - 6%), is an important active in the control of downy mildew, leaf spots and phytophthora. It is especially important in impatiens, pansy and viola. **Iprodione** (£6M - 3%) is used in botrytis control as part of a resistance management strategy, there are alternative active substances that provide some control. **Myclobutanil** (£3M - 2%) and **prochloraz** (£3M - 2%) are used in control of powdery mildew.

The removal of insecticides such as **abamectin cypermethrin** and **thiacloprid** would reduce the ability to control pests in bedding and pot plants. **Abamectin** (£2M - 1%), is used in the control of red spider mite and leaf miners. The loss of broad spectrum insecticides **cypermethrin** (£1M - 1%), and **thiacloprid** (£3M - 2%) would result in further yield losses.

Scenario 2 – Above plus difenoconazole, penconazole, propiconazole, thiophanate-methyl, deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £40M – 19% reduction in farmgate value.

Fungicides such as **difenoconazole** (£0.3M - <1%), **penconazole** (£0.3M - <1%) and **propiconazole** (£2.5M - 1%) are used on small areas of the crop (less than 3%) for the control of a range of diseases including powdery mildew, rhizoctonia, leaf spots and rusts. The loss of these active substances will have a direct impact on yield losses and costs in those crops where they are used. **Thiophanate-methyl** (£2.0M - 1%) is used as a drench or granule against black root rot. There would be no chemical control for destructive pathogens such as *Thielaviopsis*

The removal of **deltamethrin** could result in losses of £1.0M – 1%%, the impact of this loss would be most severe in non IPM systems, particularly if other pyrethroid insecticides were no longer available. Removal of **spiromesifen** (£3.3M, 2%) is likely to result in yield losses as a result of failure to control white fly and spider mites. Spirotetramat may be a suitable substitute if available.

Scenario 3 – Above plus chlorothalonil, fosetyl-aluminium, mandipropamid, propiconazole, thiram, glufosinate-ammonium, chlorpyrifos, dimethoate, lambda-cyhalothrin, spinosad, spirotetramat,

The impact of the loss of active substances in scenario 3 is estimated to be a £63M – 31% reduction in farmgate value.

The removal of fungicides **chlorothalonil** (£0.6M - <1%), **cymoxanil, fosetyl-aluminium** £4.1M - 2%), **mandipropamid** (£1.0M - 1%), **thiram -** £0.5M – <1%). will place greater reliance on remaining active substances. More spraying with the remaining active substances may be required to maintain the levels of control required by customers resulting in increased pesticide use.

The removal of herbicides will have an effect as there is a requirement to keep non crop areas free of weeds to prevent weed seeds contaminating crops. Historically **glufosinate-ammonium** (£10.9M, - 4%) has been used in non-cropped areas.

The removal of insecticides **chlorpyrifos** and **lambda-cyhalothrin** will be less of an issue than the loss of **cypermethrin** or **deltamethrin**, which are the pyrethroids of choice, further losses are expected following the withdrawal of **spinosad** (£8.3M - 5%) and **spirotetramat** (£0.6M - 15%),

On the phalaenopsis crop **chlorpyrifos** is the only effective control for bark living mosquito larvae (‘pot worm’), significant crop losses would be expected if it were withdrawn.

Conclusion

The main disease problems in bedding and pot plants grown under protection are downy mildew, powdery mildew, botrytis, leaf spots, black root rot and stem base rot. Improvements in production hygiene and environmental control under protection will always help to prevent disease problems from establishing. Early detection and timeliness of operations will also help to control the spread of diseases and also assist in the control of pest problems, such as white fly, red spider mite and thrips.

Disease prevention starts with implementing appropriate cultural practices during production. Inspection of imported and incoming plant material for signs of existing infections is essential, along with good hygiene and plant quarantine practices. The separation of seed-raised crops from plants raised from cuttings is another example of a sensible horticultural practice, to prevent the transfer of disease.

Good control of humidity and the use of consistent air movement in the growing structures are also important. Prompt removal of any diseased material will also help to contain the spread of disease.

Finally and, perhaps, most importantly, the use of preventative pre-emergence fungicides and products containing active ingredients based on different chemical groupings, are also essential to maintain control of fungal pathogens, such as downy mildew.

In the case of powdery mildew, good control has been achieved with the use of triazoles, such as **myclobutanil**. Strobilurins have also proved effective against powdery mildew, for example boscalid and pyraclostrobin. In addition, azoxystrobin will provide limited control.

Leaf spots will spread rapidly, so early treatment with fungicides is essential. Suitable active ingredients include **mancozeb**.

Although there are a range of microbial pesticides now available to target a range of fungal diseases, there remains heavy reliance on a number of active ingredients to control devastating fungal problems, such as botrytis, downy mildew, powdery mildew and leaf spots. It will also be essential to have access to a range of active ingredients from different chemical groupings, in order to prevent fungal resistance to chemicals going forward.

As there would appear to be a consistent threat from the introduction of new pests and diseases from imported plant material in to the UK, it will also be essential to retain active ingredients with more broad-spectrum activity, for example **deltamethrin** and **abamectin** against pest species.

Herbicides are not used in the pot and bedding plant production processes, but the control of weeds outside the growing structures is required on an annual basis. However, glyphosate remains available and is not currently considered as an endocrine disruptor.

The loss of the aforementioned fungicides and insecticides is likely to result in increased use of contact pesticides or biopesticides as biological controls can be too slow or expensive on short term bedding crops.

Bulbs and outdoor flowers (BOF) include the following; Narcissi Bulbs and Flowers £18.7M - Gladioli flowers £2.8M - Sweet William flowers £1.6M - Aster flowers £1.5M - Sunflowers £2.0M - and Peaonia £1.5 M.

This gives an unaccounted crop valued at £8.9M for minor bulb (tulips and lilies) and flower crops for which accurate estimate for this impact was not possible, but it is probable that the impact will be similar to the known crops, with some being heavily affected and some not. The total farmgate value of the crop is £37M.

Scenario 1 – Cyproconazole, epoxiconazole, mancozeb, iprodione, prochloraz, tebuconazole, linuron, cypermethrin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £5M – 15% reduction in farmgate value.

The fungicides lost in this scenario are widely used in gladioli production, but there are alternatives available that would provide adequate levels of control. **Epoxiconazole** (£2M - 6% of BOF farmgate value) and **tebuconazole** (£2M - 6% of BOF farmgate value) are both used for foliar disease control (white mould - *Ramularia vallisumbrosae* and Smoulder - *Sclerotina polyblastis*) in narcissus and in their absence it is expected that there would be combined bulb and flower yield losses of approximately 20%, up to 40% in bad years.

Cyproconazole, **epoxiconazole** and **tebuconazole** are used in Sweet Williams for Ring spot (*Mycosphaerella dianthi*), Leaf spot (*Cladosporium echinulatum*) and rust (*Uromyces coryophyllinus*) control. The crop's long growing season from September to April requires a constant fungicide programme to prevent the leaf diseases becoming uncontrollable. Potential loss 10%.

Although both **cypermethrin** (caterpillars) and **thiacloprid** (aphids) are widely used for aster and gladioli production there are alternative active substances available that could provide adequate control.

Narcissus - Scenario 1 would have an impact upon yields of both flowers and bulbs (Defra 2012 statistics output bulbs £10.4M & flowers £8.3M) and a reliance upon a limited range of products would result in a poor resistance strategy leading to a probable increased disease pressure in the future

Scenario 2 – Above plus difenoconazole, propiconazole, metribuzin, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £8M – 21% reduction in farmgate value.

The additional loss of **difenoconazole** and **propiconazole** to the Sweet William growers would result in further challenges to the control of Ring spot (*Mycosphaerella dianthi*), Leaf spot (*Cladosporium echinulatum*) and rust (*Uromyces coryophyllinus*). Potential losses of 15%.

Propyzamide and **metribuzin** are widely used, but alternatives remain available.

Deltamethrin is also used for caterpillar control, but alternative active substances remain available.

Narcissus - Scenario 2 would create further disease control problems and yield loss, which in a crop of a very high capital cost to enter and maintain would require increased returns. The flower crop is becoming of increasing importance to the crop as bulb sales remain static with exports being of importance.

Scenario 3 – Above plus chlorothalonil, prothioconazole, chlorpropham, lenacil, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £14M – 48% reduction in farmgate value.

Chlorothalonil (£4M – 11%) is used to dip narcissus bulbs to control base rot. In the absence of chlorothalonil (combined with the loss of **tebuconazole** and **prochloraz** in scenario 1) yield losses of 20% could be expected in narcissus crops.

The loss of **prothioconazole**, in addition to the fungicides lost in scenario 1 and 2, would result in further losses to Ring spot, Leaf spot and rust (Potential losses 15%).

The combined loss of **thiacloprid** (£0.2M – 1%) and **spirotetramat** (£0.3M – 1%) leaves little control of certain aphid species (combined losses of 25% possible in asters, 5% in gladioli the absence of control). Growers would be reliant upon pirimicarb (for which most of the aphids are resistant), pymetrozine and acetamiprid for season long control. The loss of **lambda-cyhalothrin** (£0.1M - <1%) and **spinosad** (£0.3M – 1%) would mean there would be few available options for caterpillar control in gladioli and loss of spinosad would also reduce thrips control. Yield losses would occur as a result of crops failing to achieve required quality specifications with remaining active substances.

***Narcissus* -** Scenario 3 would be of greater importance to the South West producers, who now produce the majority of the cropped area. Lack of control measures for Large Narcissus Fly may well increase its distribution area.

The potential loss of yield of both bulbs and flowers resulting in a reduced income of over 50% would place the crop in a severe financial situation which puts the whole crop into an uneconomic situation as it is unlikely that farmgate prices would double to compensate for yield losses.

Hardy Nursery Stock

The hardy nursery stock make up the largest part of the ornamental horticulture sector having a farm gate value of £1 billion, with an estimated crop area of 5000ha.

Scenario 1 – iprodione, mancozeb, myclobutanil, prochloraz, tebuconazole, linuron, abamectin, cypermethrin, fenoxycarb, thiacloprid,

The impact of the loss of active substances in scenario 1 is estimated to be a £381M – 28% reduction in farmgate value.

In scenario 1 there are a number of fungicides that are lost which provide key disease control. **Iprodione** (£24M - 2%) is used for control of a range of diseases including botrytis,

sclerotinia, fungal leaf spots, phoma and rhizoctonia. **Mancozeb** (£12M - 1%) is used for downy mildew control, it is especially important as a protectant early in the growing season, loss would make achieving control more difficult. **Myclobutanil** (£24M – 2%) and **prochloraz** (£72M – 7%) are widely used in powdery mildew control programmes as they are crop safe and myclobutanil is an essential product given that the number of applications of many of the alternatives are restricted, its loss may result in more use of less efficient products as there is no direct replacement given the fact that may also be removed. If both myclobutanil and prochloraz were removed no widely used, safe alternatives within this fungicide group would remain for use in the production of container grown stock.

The loss of the herbicide **linuron** (£0.6M - <1%) would result in increased pressure on the use of other residual herbicides which may lead to development of resistance and reduced control in the future. Weed control is critical as customers reject plants showing any sign of infestation, mulching requires investment in expensive machinery and will not provide 100% control. Use of hand weeding significantly increases the cost of production (30% increase compared to herbicides) and is therefore not justified based on the value of the crop.

The loss of the insecticide **abamectin** (£108M – 11%) would have severe impacts as this is the only product with semi-systemic activity to control TSSM (two-spotted spider mite) that can be used in IPM - Integrated Pest Management systems). The use of full biological control for the control of TSSM is also estimated to increase costs by at least 25% (not captured in these figures). Temperature limitations and restrictions on the use of certain biological controls would be a problem. Other plant protection products that are less compatible with biological controls would have to be used to control other pests e.g. leaf miner. Problems outlined may result in a reduction in the use of biological controls, which would be a backward step.

The loss of **cypermethrin** (£1.8M - <1%) and **fenoxycarb** (£0.6M <1%) could result in modest additional losses of yield, and further deplete the armoury against caterpillars.

Thiacloprid (£36M – 4%) is the only effective soil incorporated insecticide for the control of vine weevil (the product is systemic so has an effect on sap feeding pests). Vine weevil is a major pest of container grown nursery stock. The national vine weevil population on nurseries has increased in recent years following the loss of other soil incorporated insecticides. Therefore, pest pressure is significantly higher than it has been in recent years. Parasitic nematodes can be used instead but two applications are required to achieve control, resulting in extra labour costs. The growing media has to be kept moist following the use of nematodes which does not suit all plant species, this can result in further losses from root pathogens. Unless nematodes are applied thoroughly by skilled

staff it is difficult to achieve 100% control. Less than 100% control is likely to result in customer rejections.

The hardy nursery stock crop relies on a 'perfect blemish free product, with any sign of pest or damage resulting in loss of sales. There are already a restricted number of active substances available to the crop and any additional losses of active substances increases the risk of damage and resultant sales losses. The industry is already producing plants with very tight sales margins and as a result any increase in cost of production, or reductions in the proportion of marketable crop will have severe implications for the crop. Where control cannot be achieved some growers are expected to cease production.

Scenario 2 – Above plus bupirimate, difenoconazole, penconazole, thiophanate-methyl, metribuzin, propyzamide, deltamethrin, spiromesifen

The impact of the loss of active substances in scenario 2 is estimated to be a £316M – 32% reduction in farmgate value, with many growers expected to cease production reducing the value still further.

The additional loss of the fungicides in scenario 2 in combination with those lost in scenario 1 would have severe implications on the ability to produce disease free HNS plants. There would be no chemicals control for destructive pathogens such as *Thielaviopsis.* **Bupirimate** (£24M – 2%), is used to control a range of powdery mildew types with eradicant and protectant activity, making it an important part of the fungicide armoury. The loss of **difenoconazole** (£0.6M - <1%), **propiconazole** (£0.6M <1%), **penconazole** (£1.2M - <1%) and **thiophanate-methyl** (£1.2M - <1%) will have a direct impact on yield losses and costs through reduced disease control.

The loss of herbicides such as **metribuzin** and **propyzamide** would affect up to 30% of crops. In some instances there may be problems with crop safety with alternatives which would prevent use, resulting in significant hand weeding which is expensive. Alternative residual herbicides could be utilised however this may accelerate problems with resistance.

The impact of the removal of **deltamethrin** (£3.6M - <1%) would be most severe in outdoor production and non IPM systems, particularly if other pyrethroid insecticides were no longer available. It is used for the control of aphids, whitefly and other sucking pests. Removal of **spiromesifen** (£1.8M - <1%) is likely reduce control of spider mite, especially in protected crops. Spirotetramat may be a suitable substitute if available.

Scenario 3 – Above plus chlorothalonil, cymoxanil, fluazinam, fosetyl-aluminium, mandipropamid, propiconazole, thiram, 2,4-D, dimethenamid-p, ethofumesate, fluazifop-p-butyl, glufosinate-ammonium, lenacil, s-metolachlor, tepraloxydim, terbuthylazine, chlorpyrifos, lambda-cyhalothrin, spinosad, spirotetramat, dimethoate.

The impact of the loss of active substances in scenario 3 is estimated to be a £485M – 48% reduction in farmgate value.

The impact of reduced disease control could reduce the value of the hardy nursery crop by £208M – 21%. The removal of fungicides **chlorothalonil**, **cymoxanil, fluazinam**, **fosetyl-aluminium**, **mandipropamid, prothioconazole** and **thiram** will place greater reliance on remaining active substances and the loss of broad spectrum protectants such as **chlorothalonil** will make the control of some diseases more difficult. More spraying with the remaining active substances may be required to maintain the levels of control required by customers resulting in increased pesticide use and carbon emissions.

The impact of reduced weed control could reduce the value of the hardy nursery crop by £86M – 9%. The removal of herbicides such as **2,4-D**, **dimethenamid-p**, **ethofumesate** and **fluazifop-p-butyl** will reduce the options available for weed control, especially grasses, although only used on a limited area of the crop (10%). **Glufosinate-ammonium**, **lenaci**l, **S-metolachlor**, **tepraloxydim -** especially for annual meadow grass control) and **terbuthylazine** (important for groundsel control) are used on 50-70% of the crop area, the loss of residual and post emergence controls will place increased reliance on mechanical and hand weeding which is significantly more expensive than controlling weeds with herbicides.

The impact of reduced pest control could decrease the value of the hardy nursery crop by £191M – 19%. The removal of insecticides **chlorpyrifos**, **lambda-cyhalothrin**, **spinosad**, **spirotetramat**, and **dimethoate** is likely to result in increased use of biological controls and or regular applications of the remaining authorised insecticides. Loss of chlorpyrifos and lambda-cyhalothrin will leave crops open to vine weevil damage, with limited alternatives available.

Dimethenamid-p, S-metolachlor and spirotetramat are only recent introductions to the HNS crop following trial work.

Conclusion

Control of pathogens, pests and weeds in hardy nursery stock is vitally important as low levels can either render crops unsaleable or result in extra costs to control the problem. Deciduous crops can be sold once they have defoliated, but this is not an option for evergreen crops. These would have to remain on the nursery until there was sufficient clean growth to enable them to be sold. Both options increase the cost of production, with crops that stay too long likely to completely erode any profit margin. Pesticides availability to HNS is already limited, with many only available through EAMUs or Long term Agreements for Extension of Use.

Many fungicide programmes (e.g. powdery mildew) already use all of the authorised active substances in order to achieve control, whilst minimising the risk of fungicide resistance. Loss of fungicides from different fungicide groups increases the risk of fungicide resistance occurring. Loss of powdery mildew control could render a number of crops, including susceptible rose species, unviable.

The loss of herbicides will impact most on field production and is likely to result in more mechanical weed control in field grown crops in order to minimise costs, this will result in increased soil erosion (resulting in water pollution; eutrophication and herbicide residues) on sloping sites as light soils, prone to erosion are generally used for HNS field production.

The loss of insecticides, particularly those used in IPM will make it increasingly difficult and costly to manage hotspots of key pest species, resulting in extra costs through repeat applications of contact acting pesticides or increased use of biological controls. This will result in difficulties in controlling key pests at certain times of year which is likely to result in increased wastage.

In non IPM systems the use of insecticides from fewer insecticide groups will hasten the development of resistance to remaining, effective treatments. Resistant pests are likely to spread in the trade, which will make pest control difficult for the crop as a whole.

The HNS crop group employs approximately 250,000 people. Many of these jobs would be put at risk, especially with the cumulative losses in scenarios 2 and 3, with nurseries expected to cease production as profit margins become tighter. There would be an increased reliance on imports from the EU (if they were able to continue to function with these restrictions) or further afield.

Other edible crops

Cereals

The total farmgate value of the cereals crop group (wheat, winter barely, spring barley, oats, rye, triticale) is estimated at £3,374M per year (Table 23), with approximately 2.9M ha of cereal crops grown each year. The largest crop in terms of area grown and value is the wheat crop at £2,482M per year, with the barley crop (winter and spring) accounting for a further £787M.

Table 23 Summary of economic losses £M - based on yield loss only, in cereal crops across the three scenarios of endocrine disrupting pesticide loss

Crop area	(Kha)	Winter wheat, 1,833	Winter barley, 357	Spring barley, 617	Oats 127	Rye 6	Triticale 17	Maize (grain) 3	Maize (forage) 170	Cereals 3,129
Production	(Kt)	13,700	2,300	3,300	700	32	128	23	6,500	26,682
Farmgate value	(£M)	£2,482	£293	£494	£82	£5	£19	£4	£204	£3,582
Scenario 1	Fungicides	£12	£0	£0	£0	£0	£0	£0	£0	**£13**
Scenario 1	Herbicides	£0	£0	£0	£0	£0	£0	£0	£0	**£0**
Scenario 1	Insecticides	£0	£0	£0	£0	£0	£0	£0	£0	**£0**
Scenario 1	All pesticides	£12	£0	£0	£0	£0	£0	£0	£0	**£13**
Scenario 2	Fungicides	£20	£0	£0	£0	£0	£0	£0	£0	**£20**
Scenario 2	Herbicides	£0	£0	£0	£0	£0	£0	£0	£0	**£0**
Scenario 2	Insecticides	£0	£0	£0	£0	£0	£0	£0	£0	**£0**
Scenario 2	All pesticides	£20	£0	£0	£0	£0	£0	£0	£0	**£20**
Scenario 3	Fungicides	£174	£9	£10	£0	£0	£1	£0	£0	**£194**
Scenario 3	Herbicides	£0	£0	£0	£0	£0	£0	£1	£20	**£21**
Scenario 3	Insecticides	£13	£0	£0	£0	£0	£0	£0	£8	**£22**
Scenario 3	All pesticides	£187	£9	£10	£0	£0	£1	£1	£28	£237

Scenario 1 – Epoxiconazole, mancozeb, maneb, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin, thiacloprid

Based on the expert summaries of the individual crops in this crop group it is estimated that a loss of the approved active substances in scenario 1 would cost the crop £13M - 0.4% in reduced yield, with largest losses in wheat (£12M - 0.5%), with a loss of the rust active fungicides (especially **epoxiconazole** £9M – 0.3%) expected to cause the greatest loss of yield. Rust control in triticale would also be impacted.

Scenario 2 – Above plus thiophanate-methyl, difenoconazole, folpet, fluquinconazole, propiconazole, triticonazole, deltamethrin

In scenario 2 the yield cost to the crop would rise to £20M - 0.6%), although most of this additional yield loss is associated with the loss of the take-all active fungicide **fluquinconazole** – which could be replaced with **silthiofam** until both are lost in scenario 3.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, silthiofam, thiram, 2,4-D, pinoxaden, beta-cyfluthrin, chlorpyrifos, clothianidin, dimethoate, lambda-cyhalothrin

In scenario 3 the yield cost to the cereal crop group is estimated at £237M - 7%, with the largest losses from wheat (£187M - 8%), spring barley (£10M - 2%) and winter barley (£9M - 3%). The yield losses are predominantly (£174M - 4%) related to a loss of most of the azole fungicides, therefore limiting the ability to control disease in most cereal crops, with

increased reliance on a smaller number of modes of action, in addition loss of both take-all acting fungicides results in further yield losses from wheat and winter barley (£20M). In addition there is a reduction in farmgate value associated with reduced pest control (£13.5M – 1%).

Winter Wheat

There are approximately 1,833,600 ha of winter wheat grown in the UK, with an estimated farmgate value of £2,482M.

Scenario 1 – Epoxiconazole, mancozeb, maneb, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £12M – 0.5% reduction in farmgate value.

Scenario 1 includes four triazoles and one imidazole. These active substances are very useful as both preventative and curative broad spectrum fungicides. In particular, they provide good control of *S. tritici*, yellow and brown rust and *Fusarium* sp. **Epoxiconazole** (£9M – 0.4%) is one of the more effective azoles on the market and one of the most commonly used fungicides on wheat. The active substances lost in this scenario are the main rust (yellow and brown) active azoles, although there are other modes of action with rust activity (for example the strobilurins and SDHI's) and other azoles such as **prothioconazole** also have some useful activity against rust (yellow and brown), the loss of these key active substances in scenario 1 would mean that overall disease control would be compromised, resulting in a 0.5% yield reduction, equivalent to £12.4M / year.

Scenario 2 – Above plus thiophanate-methyl, difenoconazole, folpet, fluquinconazole, propiconazole, triticonazole, deltamethrin

No further impact of the loss of azoles in this scenario as **prothioconazole** remains.

The use of the same active ingredient is not recommended for resistance management, and it is highly likely that the efficacy of prothioconazole on *Septoria tritici* would decrease more rapidly over time. As a seed treatment, **fluquinconazole** offers some protection against take-all. Loss of fluquinconazole would mean greater reliance on silthiofam for take-all but also the need for addition inputs for early foliar disease control. This would likely have an additional cost implication, but no immediate effect on yield, the impacts would occur once silthiofam was also removed.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, silthiofam, thiram, 2,4-D, pinoxaden, beta-cyfluthrin, chlorpyrifos, clothianidin, dimethoate, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £187M – 8% reduction in farmgate value.

If **prothioconazole** (£42M - 2%) and **chlorothalonil** (£41M - 2%) were lost (along with all other active substances under scenario 1 and 2), there would be more significant yield losses expected, due to further reductions in rust control and loss of fusarium head blight control. In addition the control of *S. tritici* would be completely dependent on SDHI fungicides. This mode of action is considered to be at moderate to high risk of resistance development. The loss of azoles and other fungicides under scenario 3 would significantly increase the risk of resistance development in SDHI's. Resistant management strategies rely on the use of at risk fungicides in mixtures with a mixture partner at a rate offering robust control and/or a multi-site active product. Effective products falling into those categories would not be available under this scenario. The control of rusts would also be more reliant on other less effective modes of action, namely strobilurins, SDHI's, spiroxamine and morpholines.

Impacts are calculated based on immediate impact at current levels of control, however with a reduced range of modes of action it is expected that diseases such as *S. tritici* will develop resistance to remaining active substances more quickly than they would have done in presence of other modes of action.

Chlorothalonil is a very important multi-site fungicide for the control and resistance management of *S. tritici*. Its loss coupled with the loss of the azole fungicides would result in some reduction in farmgate value (3%) across the treated area, this is equivalent to a £41M /year. In addition the loss of this active increases the risk of resistance development to SDHI fungicides and the potential for yield losses if resistance develops is even greater.

The net loss of **fluquinconazole** (£13M) and **silthiofam** (£13M) would mean that no chemical options were available for the control of take-all. An estimated loss of 6% yield would result on the 14% of crops that are treated. Rotation is an effective method for take-all control, without a chemical option for control it may be difficult to grow second or third wheat crops in certain fields, although measures to mitigate losses can be taken e.g. later sowing, growing continuous wheat (take-all decline).

Taking into account all fungicides lost in Scenario 3 the estimated economic loss is £174M – 7%. It is also highly likely that the yield loss would increase each year due to decreased target sensitivity to the remaining fungicides (mainly the SDHIs and strobilurins) due to resistance.

Affected herbicides approved for use on wheat crops are only used on relatively small areas. Given this and the high number of alternative products available, no economic loss would be expected.

Although the loss of each individual insecticide would be minimal, the loss of all of these insecticides would have an effect on yield. There would be no remaining active substances for the control of OWBM, leatherjackets or frit fly and the only option for wheat bulb fly would be tefluthrin seed treatment which may not protect earlier sown crops. The estimated net loss of all insecticides would be £13M – 1%

Conclusions

The main impact of scenario 1 in wheat would be a reduction in the active substances available for disease control, limiting resistance management options and weakening the options available for rust control. This will result in slight (0.5%) yield impacts costing the crop £12M in reduced value.

Scenario 2 would result in no further impact on yield as long as prothioconazole remains for disease control. However, the loss of further azoles puts greater pressure on resistance management strategies.

The loss of **prothioconazole** (£42M - 2%) and **chlorothalonil** (£41M - 2%) in scenario 3 on top of those active substances lost in scenarios 1 and 2 would result in further reductions in rust control and a loss of fusarium head blight control. The additional loss of these actives would also mean that there would be the complete loss of two modes of action in resistance management strategies, putting increased pressure on the remaining SDHIs and strobilurins. The combined loss of insecticides would also have a small (1%) impact on yield, reducing the value of the crop by £13M.

Winter Barley

There are approximately 356,800 ha of winter barley grown in the UK, with an estimated farmgate value of £293M.

Scenario 1 – Cyproconazole, epoxiconazole, maneb, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin

No expected yield impact – sufficient alternatives remain.

Scenario 2 – Above plus folpet, fluquinconazole, propiconazole, triticonazole, deltamethrin

No expected yield impact – sufficient alternatives remain.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, silthiofam, thiram, 2,4-D, pinoxaden, beta-cyfluthrin, chlorpyrifos, clothianidin, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £9M – 3% reduction in farmgate value.

The loss of all triazole fungicides would impact on disease control, timing and duration of protection against foliar and ear diseases, including *Rhynchosporium* sp. The estimated economic loss due to the loss of azoles is £8.9M. SDHI and strobilurin fungicides would remain and are almost as effective as the triazoles against a range of barley diseases, however, triazoles especially **prothioconazole** (£4M – 1%) are highly effective on nearly all of the diseases of barley, as such are a key part of the resistance management strategy. Their loss would impact on current guidelines to prevent the development of fungicide resistant to at-risk groups e.g. SDHIs.

The loss of **silthiofam** and **fluquinconazole** would leave no chemical options for the control of take-all. This is less important in barley than it is in wheat, however a small reduction in farmgate value may result, 2% of area treated and yield losses of 5%. The estimated economic loss is £0.3M.

The main target for pest control in winter barley is aphids (BYDV vectors). Scenario 3 would see the loss of the majority of insecticides which are available for aphid control. A few active substances would remain (pyrethroids and a carbamate), but there would be no options for seed treatments and there would be a need for addition spray timings to maintain an adequate level of control. The loss of cypermethrin and chlorpyrifos would leave no options for the control of gout fly or frit fly. Yield losses of 1% for each pest on affected crops can be assumed, but the area affected is very low so estimated economic impact is £117K.

Conclusion

The loss of active substances in scenarios 1 and 2 would have minimal impact on winter barley yields with sufficient alternative active substances available to maintain control. The loss of all azole fungicides, especially prothioconazole in scenario 3 would make disease control more difficult and reliant on a smaller number of modes of action, increasing the risk of resistance development in target species. Economic impact would be minimal and barley production could be maintained.

Spring Barley

There are approximately 616,800 ha of spring barley grown in the UK, with an estimated farmgate value of £494M.

Scenario 1 – Cyproconazole, epoxiconazole, maneb, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin

No expected yield impact – sufficient alternatives remain.

Scenario 2 – Above plus folpet, propiconazole, deltamethrin

No expected yield impact – sufficient alternatives remain.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, thiram, 2,4-D, pinoxaden, beta-cyfluthrin, chlorpyrifos, clothianidin, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £10M – 2% reduction in farmgate value.

This scenario would result in the loss of **prothioconazole** (£5M – 1%), as well as all the other azoles lost in scenario 1 and 2. Prothioconazole is a key tank mixture partner and also available as co-formulations with SDHIs and strobilurins. It is expected that in the absence of azoles spring barley crops would suffer a 2% yield reduction, despite the availability of alternative active substances, this equates to a £10M /year, cost to the crop. The use of SDHIs alone would increase the risk of resistance development.

Multisite fungicides are a key part of anti-resistance strategies and the loss of **chlorothalonil** would impact on resistant management strategies, particularly if no alternative mixture partners were available from other chemical groups e.g. triazoles.

Pinoxaden is widely used for blackgrass, ryegrass and wild oats control in spring barley up to GS41, the loss of this herbicide would leave no options for control after GS30. There is, however, widespread resistance in blackgrass, ryegrass and wild oats to pinoxaden. The loss of the herbicide would place more emphasis on early season weed control, but there would be no yield losses expected.

2,4-D and **ioxynil** provide alternative modes of action to sulfonyl urea (SU) herbicides for the control of broad-leaved weeds and form a valuable component of resistance management plans. The loss of both of these active substances could compromise the control of SU resistant broad-leaved weed species.

The combined loss of **cypermethrin** and **chlorpyrifos** would leave no options for control of gout fly, frit fly or leatherjackets. The area affected by these pests is small (4% total) but where present, yield losses of 1%, 0.5% and 0.5%, respectively, could be expected. The estimated economic loss of this is £0.4M.

Conclusion

Scenarios 1 and 2 are not expected to have any significant impact on spring barley production as sufficient alternative active substances remain available. The loss of prothioconazole and chlorothalonil in addition to the fungicides lost in scenarios 1 and 2 is expected to reduce yields by about 2% (£10M). There would be increased pressure on the remaining active substances, compromising resistance management strategies.

Oats

There are approximately 126,600 ha of oats grown in the UK, with an estimated farmgate value of £82M.

Scenario 1 – Cyproconazole, epoxiconazole, prochloraz, tebuconazole, ioxynil, cypermethrin

No expected yield impact – sufficient alternatives remain.

Scenario 2 – Above plus difenoconazole, propiconazole, triticonazole, deltamethrin

No expected yield impact – sufficient alternatives remain.

Scenario 3 – Above plus prothioconazole, thiram, 2,4-D, beta-cyfluthrin, chlorpyrifos, clothianidin, lambda-cyhalothrin

Disease pressure in oats is lower than other crops, and it is expected that in a typical year there would be sufficient alternative fungicides available to maintain control of key diseases such as crown rust and mildew. However, with a reducing range of active substances available there is an increasing risk of resistance build up to the remaining active substances, rendering them less effective in the future.

Affected herbicides approved for use on oat crops are only used on relatively small areas. Given this and the high number of alternative products available, no economic loss would be expected. **2,4-D** and **ioxynil** provide alternative modes of action to SU herbicides for the control of broad-leaved weeds and form a valuable component of resistance management plans. The loss of both of these active substances could compromise the control of SU resistant broad-leaved weed species.

The combined loss of **cypermethrin** and **chlorpyrifos** would leave no options for control of frit fly or leatherjackets. The area affected by these pests is small with minimal yield impacts expected.

The loss of **clothianidin** would leave no options for the control of leafhoppers (9% of area treated), but these have little economic impact.

Conclusion

The impacts of scenarios 1 and 2 would be minimal, with sufficient alternative active substances available to maintain control of key disease, weed and pest species. The additional losses in scenario 3 would make weed control more challenging, but in in most cases sufficient control could be maintained. Certain pests would become more difficult to control, but given the small area affected and the small reductions in yields it is estimated that the yield impact would be minimal.

Rye

There are approximately 5,500 ha of rye grown in the UK, with an estimated farmgate value of £4.8M.

Scenario 1 – Cyproconazole, epoxiconazole, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin

Rye is susceptible to brown rust and with the loss of key rust active substances in this scenario (**epoxiconazole** and **tebuconazole**) there would be a reduction in efficacy of brown rust control. Estimated impact is a 0.2% yield impact, costing £10,000 / year. Other azoles would be replaced with remaining azoles, e.g. prothioconazole. Loss of **prochloraz** would result in increased reliance on prothioconazole + clothianidin or carboxin + thiram seed treatments for foot rot, but no significant yield or economic impacts.

Scenario 2 – Above plus difenoconazole, fluquinconazole, propiconazole, triticonazole, deltamethrin

No additional yield impact – sufficient alternatives remain.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, silthiofam, thiram, 2,4-D, beta-cyfluthrin, chlorpyrifos, clothianidin, lambda-cyhalothrin

The loss of all azoles in Scenario 3 would reduce effectiveness of disease control programmes, limiting the available chemistry and ability to manage resistance. There is insufficient trial data available for yield response to treatment to provide an accurate assessment of losses, but based on impacts in other cereals modest yield reductions, predominantly as a result of reduced rust control, are predicted (3%) with an estimated impact of £144,000 /year.

The combined loss of all insecticides included in Scenario 3 would result in no options for the control of leatherjackets or slugs. The area affected by these pests is small (4% area),

but where present, yield losses of 0.5% for each pest could be expected. The estimated economic loss of this is £2,000 /year.

Conclusion

The loss of rust active fungicides (**epoxiconazole** and **tebuconazole**) in scenario 1 would result in some reduced rust control. Further losses of azoles, specifically **prothioconazole**, in scenario 3 would increase the yield losses from rusts. However, the impacts would remain modest and production of this crop would remain viable in all but the most high disease pressure years.

Triticale

There are approximately 17,000 ha of triticale grown in the UK, with an estimated farmgate value of £18.5M.

Scenario 1 – Cyproconazole, epoxiconazole, metconazole, prochloraz, tebuconazole, ioxynil, cypermethrin

Triticale is susceptible to yellow rust and in scenario 1 the key rust active ingredients, especially **epoxiconazole**, are lost. Therefore it is estimated that yellow rust control would be impacted, with reliance moving to active substances that are slightly less effective (**prothioconazole**). Yield impacts are forecast at 3%, resulting in a reduction in farmgate value of £460,000 /year.

Scenario 2 – Above plus difenoconazole, fluquinconazole, propiconazole, thiophanate-methyl, triticonazole, deltamethrin

No additional yield impact – sufficient alternatives remain.

Scenario 3 – Above plus carbendazim, chlorothalonil, prothioconazole, silthiofam, thiram, beta-cyfluthrin, chlorpyrifos, clothianidin, dimethoate, lambda-cyhalothrin

Triticale is highly susceptible to yellow rust. In scenario 3 the last effective rust active fungicide would be lost (**prothioconazole**). This would leave no good control options for rust. As a result it is estimated that yield losses of 5% could occur in a typical year, equating to a reduction in farmgate value of £920,000 /year.

The loss of all insecticides would leave no options for the control of leatherjackets, leafhoppers, wireworms, snails and slugs. The area affected by each of these pests is very low to low so total economic loss is estimated at £3,000.

Conclusion

The loss of rust active fungicides (**epoxiconazole** and **tebuconazole**) in scenario 1 would result in some reduced rust control. Further losses of azoles, specifically **prothioconazole**, in scenario 3 would increase the yield losses from rusts. However, the impacts would remain modest and production of this crop would remain viable in all but the most high disease pressure years.

Maize (Grain/forage)

There are approximately 3,000 ha of grain maize grown in the UK, with an estimated farmgate value of £3.9M and approximately 170,000 ha of forage maize grown in the UK, with an estimated farmgate value of £204M.

Scenario 1 – None

Scenario 2 – None

Scenario 3 – Dimethenamid–P, terbuthylazine, chlorpyrifos

Dimethenamid-P is a major herbicide used in combination with pendimethalin for pre-emergence use in the maize crop. **Terbuthylazine** is a major herbicide used in combination with either bromoxynil or mesotrione for early post emergence weed control when yield losses are significant from weed competition. In the absence of herbicides yield losses of 10% occur in trials and may be greater. This could make the crop uneconomic, reducing the competiveness for dairy farmers who rely on forage maize as a cost effective forage source for their cattle. Therefore the potential 'knock on' loss to UK agriculture would be substantially higher.

Chlorpyrifos is used for Frit fly, which occurs as a problem on 10% of the maize area. Where Frit fly occur yield losses are very significant and average losses are 40% although total crop loss does occur.

Conclusion

If this group of active substances is withdrawn from the market it will have a severe effect on maize production in the UK.

Maize yields would be affected through increased weed competition and pest damage, causing the cost of production per tonne of maize to increase severely. Margins on dairy farmers are wafer thin already and any extra cost is likely to cause severe disruption to milk production in the UK. Causing farms to withdraw from milk production and the consequent loss of jobs within the crop

Oilseeds

The total farmgate value of the oilseeds crop group (oilseed rape, linseed, sunflower and soybean) is estimated at £693M per year (Table 24), with approximately 726,000 ha of oilseed crops grown each year. The largest crop in terms of area grown and value is the oilseed rape crop at £674M per year, with the linseed crop accounting for a further £19M. Sunflowers and soybeans are relatively minor crops in the UK.

Table 24 Summary of economic losses £M - based on yield loss only, in oilseed crops across the three scenarios of endocrine disrupting pesticide loss

		Oilseed rape,	Linseed,	Soybean,	Sunflower,	Oilseeds
Crop area	**(ha)**	**691,400**	**34,000**	**100**	**500**	**726,000**
Production	**(t)**	**2,400,000**	**59,500**	**250**	**1,250**	**2,461,000**
Farmgate value	**(£M)**	**£674**	**£19**	**£0**	**£0**	**£693**
Scenario 1	Fungicides	£4	£2	£0	£0	**£6**
Scenario 1	Herbicides	£0	£0	£0	£0	**£0**
Scenario 1	Insecticides	£0	£0	£0	£0	**£0**
Scenario 1	All pesticides	£4	£2	£0	£0	**£6**
Scenario 2	Fungicides	£4	£2	£0	£0	**£6**
Scenario 2	Herbicides	£144	£0	£0	£0	**£144**
Scenario 2	Insecticides	£0	£0	£0	£0	**£0**
Scenario 2	All pesticides	£148	£2	£0	£0	**£150**
Scenario 3	Fungicides	£100	£2	£0	£0	**£102**
Scenario 3	Herbicides	£144	£0	£0	£0	**£144**
Scenario 3	Insecticides	£0	£0	£0	£0	**£0**
Scenario 3	PGR	£0	£0	£0	£0	**£0**
Scenario 3	All pesticides	£244	£2	£0	£0	£246

Scenario 1 – Cyproconazole, iprodione, metconazole, prochloraz, tebuconazole, cypermethrin, thiacloprid

Based on the expert summaries of the individual crops in this crop group it is estimated that a loss of the approved active substances in scenario 1 would cost the crop group £6M in reduced yield, with largest losses in oilseed rape (£4M - 1%), with a loss of the PGR active fungicides **metconazole** and **tebuconazole** expected to cause the greatest loss of yield, the loss of these active substances would also impact on linseed yields reducing the value of the crop by £2M - 8%.

Scenario 2 – Above plus difenoconazole, propiconazole, thiophanate-methyl, picloram, carbetamide, propyzamide

In scenario 2 the reduction in value to the oilseed crop group would rise to £150M - 22%, with the loss of **carbetamide** and **propyzamide** and the subsequent weed control challenges in oilseed rape the predominant cause of reduction in farmgate value estimated at £141M - 20%. There could also be knock on implications for other aspects of the rotation of a failure to control problem weeds such as blackgrass in this part of the rotation. These additional costs are not captured in the calculations in this assessment.

Scenario 3 – Above plus carbendazim, prothioconazole, thiram, dimethenamid-P, fluazifop-P-butyl, glufosinate ammonium, tepraloxydim, beta-cyfluthrin, lambda-cyhalothrin

In scenario 3 the reduction in value of the oilseed crop group is estimated at £246M - 35%, with the largest reduction in oilseed rape (£244M - 36%), with the additional reduction in value associated with reduced disease control. The loss of **thiram** seed treatments in the soybean crop could make the crop unviable to grow in the UK as establishment would become unpredictable and increase the risk of growing this crop.

Oilseed Rape

There are approximately 691,400 ha of oilseed rape grown in the UK, with an estimated farmgate value of £674M.

Scenario 1 – Cyproconazole, iprodione, metconazole, prochloraz, tebuconazole, cypermethrin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £4M – 1% reduction in farmgate value.

Loss of azoles – Alternative products would be available for disease control, however, the predominant impact would be for managing large oilseed rape canopies. **Metconazole** (£2M) and **tebuconazole** (£2M) when applied for disease control can have a positive impact on yield through improving branching and decreasing crop height, however, no products with PGR activity would be available in Scenario 1.

Scenario 2 – Above plus difenoconazole, propiconazole, thiophanate-methyl, picloram, carbetamide, propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £148M – 22% reduction in farmgate value.

Loss of azoles –Control of phoma stem canker and light leaf spot would be reliant on prothioconazole, prothioconazole/SDHI co-formulations and strobilurin/SDHI co-formulations following the losses in scenario 2.

Picloram is the only post-emergence herbicide available for control of cleavers. Some pre-emergence alternatives are available for the control of these weeds, but do not control late emerging plants, so some yield loss and crop contamination may result, estimated reduction in farmgate value £3M / year. Picloram is also used to control mayweed and sow thistle, the only alternative for the control of these weeds is aminopyralid, which is currently only available in mixture with propyzamide.

There is no known resistance to **carbetamide** or **propyzamide,** these active substances are useful where resistant blackgrass is present in wheat/oilseed rape rotations. The loss of both of these active substances would have a strong negative effect on yield where blackgrass is an issue. Oilseed rape is an important break crop in cereal rotations where blackgrass is a problem so, in addition to the direct effect on yield, the loss of these crucial herbicides will compromise blackgrass control throughout the whole rotation. A conservative estimate of yield impact is 38% (on the 55% of crops treated), the farmgate cost is estimated at £140M - for oilseed rape – this does not include the impacts in the rest of the rotation.

Scenario 3 – Above plus carbendazim, prothioconazole, thiram, dimethenamid-P, fluazifop-P-butyl, glufosinate ammonium, tepraloxydim, beta-cyfluthrin, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £244M – 36% reduction in farmgate value.

The loss of **prothioconazole** (£43M – 6%) would remove one of the most effective active ingredients for controlling light leaf spot and phoma stem canker in oilseed rape from the market. Prothioconazole also has activity against sclerotinia stem rot, however, alternative products are available. Having a range of active ingredients is a key part of resistance management and this loss would mean the control of autumn diseases would be reliant on newly approved strobilurin/SDHI co-formulations alone. These are restricted to a single application and HGCA fungicide performance trials have demonstrated than more than one fungicide application would be required to control light leaf spot and phoma stem canker in a typical year. The total impact of the loss of fungicides in oilseed rape is estimated to reduce the value of the crop by £100M- 15% because of these restrictions and the loss of the triazoles.

Conclusion

In scenario 1 the loss of PGR active fungicides (**metconazole** and **tebuconazole**) would result in yield losses averaging 1% as a result of failure to control over large canopies and resultant crop lodging.

Larger impacts are seen following the withdrawal of **carbetamide** and **propyzamide** in scenario 2. In the 40-50% of oilseed rape fields affected by blackgrass the loss of these active substances could result in significant weed control failures both in crop and in subsequent crops as a result of high seed returns. Losses expected to amount to £144M - 21%, with certain rotations becoming completely unviable in locations where resistant blackgrass is present. Farmers would need to change production practices and rotations to manage the weed in areas with high populations of resistant blackgrass.

The loss of **prothioconazole** in addition to all the other fungicides in scenario 3 would have serious implications for disease control reducing the value of the crop by £100M - 15%.

Linseed

There are approximately 34,000 ha of linseed grown in the UK, with an estimated farmgate value of £18.8M.

Scenario 1 – Cyproconazole, metconazole, prochloraz, tebuconazole,

The impact of the loss of active substances in scenario 1 is estimated to be a £1.6M – 8% reduction in farmgate value.

Tebuconazole (£1.5M – 8%) is vital to linseed production providing the only form of PGR control and key disease control. Linseed is grown by some farmers with very simple agronomy, accepting that poor yields are likely in some years. Other farmers use a much more agronomy based approach to try and increase production. Experience suggests that there is typically a 5% yield response to using a fungicide application in linseed, rising to 10% in bad disease years, therefore a loss of this key active substance could reduce production on the area treated by 5-10% depending on severity of disease, using a conservative estimate (5%) to reflect a 'typical' year this is equivalent to £580,000 /year loss to the crop. There would be a small number of active substances left, but these have limited effectiveness and would not have the same level of activity against disease.

There is limited evidence available on the effectiveness of tebuconazole and metconazole in reducing lodging risk in linseed. Where lodging occurs yield losses of 50-60% are possible as a result of a combination of challenges harvesting, increased disease and reduced seed size due to shading. In a situation where 10% of the crop lodged this could cost an additional £0.94- £1.1M. In the absence of these active substances the economics of linseed production would become highly unfavourable.

Scenario 2 – Above plus difenoconazole, carbetamide, picloram

The impact of the loss of active substances in scenario 2 is estimated to be a £1.8M – 10% reduction in farmgate value.

In Scenario 2 all approved fungicides would be lost except boscalid on EAMU. This would result in an inability to effectively control disease in crops and no PGR active products being available.

Scenario 3 – Above plus fluazifop-P-butyl, glufosinate ammonium, tepraloxydim, lambda-cyhalothrin

No additional impacts expected.

Conclusion

The main impacts on linseed production come in scenario 1 with the loss of disease control and PGR activity from **metconazole** and **tebuconazole**. Further losses of fungicides in scenario 2 result in minimal options left for disease management in linseed. In a typical year yields are estimated to reduce by 10%, but in a high disease pressure year losses would be greater.

Soybean

There are approximately 100 ha of soybean grown in the UK, with an estimated farmgate value of £0.1M.

Scenario 1 – No approved active substances affected

No impact

Scenario 2 – No approved active substances affected

No impact

Scenario 3 - Thiram

Soybean seeds lack vigour. Use of **thiram** seed treatment is important for reducing the risk of damping of and ensuring good establishment of the crop and therefore suitable plant numbers. Conventional soybean crops are routinely treated with thiram. In the absence of thiram it is estimated that yield losses could range from 5-50% a year as a result of plant losses to damping off depending on the weather. In a typical year yield losses of 15% could be expected. There are currently no alternative products approved for use in soybeans. There is the potential that alternative active substances could be approved through an EAMU, but this is at a cost of at least £14,000 per active, which is not viable in such a small crop. Although soybean production in the UK is very small scale at present Soya UK suggest that it is a crop that has the potential to grow in area, providing there is suitable chemistry available to protect it.

Conclusion

Scenarios 1 and 2 would have little impact on UK soybean production, however the loss of thiram in scenario 3 could impact on the establishment of the crop.

Sunflower

There are approximately 500 ha of sunflower grown in the UK, with an estimated farmgate value of £0.3M.

No approved pesticides lost to field sunflower production.

Pulses

The total farmgate value of the pulse crop group (fresh beans – broad bean, French bean, runner bean, fresh peas – vining peas, picking peas, mange tout, edible podded and pulses – field beans and combining peas) is estimated at £237M per year (Table 25), with just over 190,000 ha of pulse crops grown each year. The largest crop in terms of area grown and value are combining pulse crops at £158M per year, with the fresh pea crops accounting for a further £58M.

Table 25 Summary of economic losses £M - based on yield loss only, in pulse crops across the three scenarios of endocrine disrupting pesticide loss

		Fresh beans	Fresh peas	Combining pulse crops	Pulses
Crop area	**(ha)**	**4,200**	**37,026**	**150,000**	**191,226**
Production	**(t)**	**26,290**	**158,630**	**594,000**	**778,920**
Farmgate value	**(£M)**	**£21**	**£58**	**£158**	**£237**
Scenario 1	Fungicides	£1	£0	£21	**£22**
Scenario 1	Herbicides	£5	£3	£6	**£14**
Scenario 1	Insecticides	£0	£4	£0	**£4**
Scenario 1	All pesticides	£6	£7	£27	**£40**
Scenario 2	Fungicides	£1	£0	£21	**£22**
Scenario 2	Herbicides	£5	£3	£9	**£16**
Scenario 2	Insecticides	£0	£5	£4	**£9**
Scenario 2	All pesticides	£6	£8	£33	**£47**
Scenario 3	Fungicides	£6	£29	£56	**£91**
Scenario 3	Herbicides	£5	£9	£9	**£22**
Scenario 3	Insecticides	£7	£13	£20	**£40**
Scenario 3	PGR	£0	£0	£0	**£0**
Scenario 3	All pesticides	£18	£51	£85	£153

Scenario 1 – Cyproconazole, iprodione, metconazole, tebuconazole, linuron, amitrole, cypermethrin, thiacloprid

The overall impact of the loss of active in scenario 1 on the pulse crop group is estimated at a £40M – 17% reduction in value. The main impacts would be a reduction in disease control, especially in the combining pulses, following the loss of **tebuconazole** (£12M – 5% reduction in value of the crop group) and **cyproconazole** (£9M – 4% reduction in value of the crop group). In addition the loss of **linuron** (£14M – 6% reduction in value of the crop group) would reduce weed control, especially in fresh beans. There are limited current pre-emergence herbicide products available in French and runner beans, as a result the loss of **linuron** would make the growing of these crops unviable except perhaps in the small, high value hand harvested market.

Scenario 2 – Above plus deltamethrin, propyzamide

The overall impact of the loss of active substances in scenario 2 is a £47M – 20% reduction in value of the pulse crop group.

The addition of **deltamethrin** (£4M – 2% to the crop group) to the list will cause severe limitations to field bean production and control of bruchid beetle, the major threat to quality in this crop. Most crops are grown for human consumption quality for export to Egypt. It is likely that sustainability of production would be severely impaired, causing large reduction in area grown. In any event, there would be substantial market losses due to down-grading of beans to feed value, making production unsustainable.

Scenario 3 – Above plus chlorothalonil, cymoxanil, thiram, fluazifop-p-butyl, glufosinate ammonium, S-metolachlor, tepraloxydim, chlorpyrifos, lambda-cyhalothrin

The overall impact of the loss of active in scenario 3 on the pulse crop group is a reduction in value of £153M – 65%.

Scenario 3 presents the greatest challenge, and under this scenario it is highly likely that fresh pea and bean crop production would be unsustainable. The combining pulses would have an increasingly marginal value within the rotation, with a likely reduction in area.

Fresh beans (broad bean, French bean and runner bean)

There are approximately 4,200 ha of fresh beans grown in the UK, with an estimated farmgate value of £21M.

Scenario 1 – Iprodione, tebuconazole, metconazole, linuron, amitrole, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £6M – 29% reduction in farmgate value.

The loss of **iprodione** (£0.5M – 2%) to control *Sclerotinia* and *Botrytis* represents the biggest threat to French and runner bean production in the UK. There would be only a single product available to control those diseases, leading to problems with resistance management. Sustainability of production would be significantly reduced. Average yield losses from sclerotinia are 5 – 30%

Loss of **tebuconazole** (£0.7M – 3%) and **metconazole** would limit available active ingredients to control rust in broad beans. The loss of tebuconazole would remove options in French and runner beans. Yield losses due to rust infection can be up to 30% in all fresh bean crops and this would particularly affect the French and runner beans crops where there is a shortage of other available active substances.

Due to the limited current pre-emergence herbicide products available in French and runner beans the loss of **linuron** (£5M – 24%) would make the growing of these crops unviable except perhaps in the small, high value hand harvested market.

Scenario 2 – Above plus deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £6M – 30% reduction in farmgate value.

Pea and bean weevil is a common pest of legumes throughout the UK and yield losses up to 25% can be sustained through larval feeding on root nodules. In addition to the loss of fungicides described in scenario 1, the loss of **cypermethrin** and **deltamethrin** (£0.1M – 1%) would impact on broad bean production. Although the problem of pea and bean weevil is less severe in Scotland and the borders, those broad beans grown in Yorkshire would be more severely affected.

Scenario 3 – Above plus chlorothalonil, cymoxanil, thiram, fluazifop-p-butyl, glufosinate ammonium, S-metolachlor, tepraloxydim, chlorpyrifos, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £4M – 1% reduction in farmgate value.

The loss of **cymoxanil**, **thiram** and **chlorpyrifos** under this scenario would lead to no seed treatments for fresh beans. Currently dwarf French beans and runner beans are imported treated with chlorpyrifos to control bean seed fly, and fungicide treatments thiram (£4M - 20%) and cymoxanil (£0.4M - 2%) are used to control damping-off, with additional activity from cymoxanil in broad beans for downy mildew. These losses, in combination with the loss of **chlorothalonil** (in mixture with metalaxyl-M) to control secondary downy mildew,

and insecticides, e.g. **chlorpyrifos** (£5M – 24%), to control pea and bean weevil and bruchid beetle, would lead to unpredictability of yield and quality, price volatility and unsustainability of production.

Conclusion

All of the scenarios present losses to the crop in production value. The loss of **iprodione** for control of *Sclerotinia* and *Botrytis* would threaten sustainability of French and runner bean production in the UK. Although the overall impact of scenarios 1 and 2 is not as severe as that in 3, they still represent significant losses in value to the crop. This would inevitably lead to price volatility due to uncertain yield and quality and less confidence in the crops in some areas. Losses would lead to increased imports to provide the current market for these products. In scenario 3, it is highly likely that these crops would no longer be grown in the UK, leading to an increase in imports from outside the EU and job losses in the vegetable industry. Negotiations and pricing could become more difficult to agree on. With the disparity with continental clearances, imported product could become even more competitive.

Fresh peas (Vining peas, picking peas, mange tout and edible podded)

There are approximately 37,030 ha of fresh peas grown in the UK, with an estimated farmgate value of £58M.

Scenario 1 – Iprodione, metconazole, amitrole, linuron, cypermethrin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £7M – 12% reduction in farmgate value.

The largest losses under scenario 1 would be through the loss of **iprodione**, **linuron** and **thiacloprid**. In the event that **iprodione** (£0.5M - 1%) becomes unavailable for use in edible podded peas (including mange tout), there would be only a single product available to control botrytis and sclerotinia, as well as ascochyta and mycosphaerella, leaving growers unable to adhere to FRAG guidelines for resistance management. Botrytis infections in fresh-picked peas cause blemishing to pods and peas, and thus complete rejection of crops.

There is only one other broad-spectrum weed control product other than **linuron** (£3M - 4%) for use in peas, Nirvana (imazamox + pendimethalin), which has following crop restrictions (particularly brassicas), limiting use for some growers, and increasing risks of resistance occurring. Other materials which are permitted for use are pendimethalin and S-metolachlor, via EAMU's and clomazone all of which are narrow spectrum at the rates allowed in vining peas. The potential of increased additional sorting costs of £25/tonne for

158,000 tonnes produced could increase costs by £0.79M – not captured in above reduction in value figures.

The loss of **thiacloprid** (£3M - 4%) would increase risk of resistance to pirimicarb as the only remaining aphicide for peas. Yield losses of 45% due to pea aphid have been experienced. It is unclear from the list provided whether zeta- and alpha -cypermethrin are at risk.

Scenario 2 – Above plus deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £8M – 13% reduction in farmgate value.

The additional loss of **deltamethrin** (£0.7M – 1%) under this scenario would further limit options for control of pea midge in those areas that suffer attacks from this pest. Pea midge affects intensive pea-growing areas in some parts of the country and the larvae feed on the flower buds, causing up to 50% yield loss. Lambda-cyhalothrin would be the only active ingredient available for control. Growers would be left unable to adhere to FRAG guidelines for resistance management. This scenario would seriously affect the ability of the UK to economically produce vining peas in most regions and put the entire crop at risk of substantial contraction. The UK would become even more reliant upon imports for this staple food.

Scenario 3 – Above plus cymoxanil, thiram, fluazifop-p-butyl, S-metolachlor, tepraloxydim, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £51M – 88% reduction in farmgate value.

Loss of **cymoxanil** (£29M – 49%) and **thiram** (£0.6M – 1%) would lead to severe disruption to the fresh pea crop as these are the only fungicidal seed treatments available for damping-off, ascochyta diseases and downy mildew in peas. Establishment of crops would be difficult and it's likely that the ability to grow these crops would not be economically feasible due to losses sustained at planting and emergence. Yield would be uncertain due to the combination of diseases that could affect these crops, and total annual production unpredictable. In the event that plants establish and crops are harvested, there would be further losses to quality, increasing uncertainty of production.

The estimated impact of a loss of weed control due to the products affected in scenario 3 is £9M – 15% reduction in value. The combination of losses in scenario 3 would make production unpredictable and significantly limit the ability to take broader measures to control blackgrass within the rotation. Whilst arguments for yield loss can be made, a large

part of the justification for using herbicides is for maintaining raw material quality. By losing certain active substances, there is greater likelihood of contaminants occurring in the harvested product. This has a financial impact, though difficult to estimate, and would lead to greater difficulties in cleaning crops prior to harvest, thus negotiations and pricing could become more difficult to agree on. With the disparity with continental clearances, imported product could become even more competitive.

Loss of the four insecticide active substances would leave only pirimicarb for aphid control and esfenvalerate for other insect pest control in picking and vining peas. Only esfenvalerate would be available in edible podded peas and mange touts. Losses in quality and production in vining and picking peas would be high due to pea moth, pea and bean weevil and midge attacks. There would be an increased risk of resistance in aphid populations to pirimicarb.

Conclusion

The three scenarios provide different challenges to the crop. In scenario 1, resistance management would become more difficult due to the loss of **thiacloprid** and **iprodione**, leaving a single active ingredient for pest and disease control in some cases.

Scenario 2 would increase the likelihood of resistance to insecticides arising, causing greater likelihood of more significant impact on crop production. In this scenario, sustainability of crop production will be more at risk.

Scenario 3 presents the greatest challenge, and under this scenario it is highly likely that fresh pea crop production would be unsustainable. This would lead to significant reduction of the area of peas grown in the UK. The loss of key active substances would lead to poor establishment and weed control, and inability to control damaging insect pests. Forecast financial loss to the UK would be complete. In this case there would be complete dependence on imported produce, and resultant job losses in this industry.

The UK is the largest producer of vining peas in the EU and there is significant investment and employment in the associated processing industry that would be impacted by a significant reduction in area grown. The vining pea crop cannot simply relocate due to the requirement to be close to the post-harvest processing facilities, facilities that are capital intense fixed assets.

Other Pulse crops (combining pea and field beans)

There are approximately 150,000 ha of other pulse crops grown in the UK, with an estimated farmgate value of £158M.

Scenario 1 – Cyproconazole, iprodione, metconazole, tebuconazole, linuron, cypermethrin, thiacloprid

The impact of the loss of active substances in scenario 1 is estimated to be a £27M – 17% reduction in farmgate value.

The loss of four key fungicides in this scenario would lead to major impact on disease control (£21M – 13%) in field beans and peas. There would be only three remaining options for disease control, two containing strobilurin active ingredients, increasing the likelihood of resistance arising, and leaving growers unable to adhere to FRAG guidelines for resistance management, the third with current approval due to expire at the end of 2015.

The loss of **linuron** (£6M - 4%) would cause poor weed control and difficult harvest conditions. Yield losses up to 50% could be sustained due to increased competition and high weed seed return would result in increased pressure on subsequent crops.

Thiacloprid is one of two insecticides approved for use in combining peas against aphids. Loss of this active would increase risk of resistance development to the remaining active, pirimicarb.

Scenario 2 – Above plus thiophanate methyl, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £33M – 21% reduction in farmgate value.

The loss of **propyzamide** (£3M – 2%) represents a significant threat to UK production of arable crops, as this active ingredient is important as part of blackgrass control strategies. It is one of the few with no known resistance issues. High infestations of blackgrass can cause yield reductions up to 80% in subsequent crops and the loss of this active would call into question the value of break crops as part of an anti-resistance strategy to control the greatest threat to combinable cropping in the east of England.

The addition of **deltamethrin** (£3M – 2%) to the list will cause severe limitations to field bean production and control of bruchid beetle, the major threat to quality in this crop. Most crops are grown for human consumption quality for export to Egypt. It is likely that sustainability of production would be severely impaired, causing large reduction in area grown. In any event, there would be substantial market losses due to down-grading of beans to feed value, making production unsustainable.

Scenario 3 – Above plus chlorothalonil, cymoxanil, thiram, fluazifop-P-butyl, glufosinate ammonium, S-metolachlor, tepraloxydim, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £85M – 53% reduction in farmgate value.

Loss of **cymoxanil** (£5M - 3%) and **thiram** (£1M - 1%) would lead to severe disruption to the pulse crop as these are the only fungicidal seed treatments available for damping-off, ascochyta diseases and downy mildew in peas and beans. Establishment of crops would be difficult and it's likely that the ability to grow these crops would not be economically feasible due to losses sustained at planting and emergence. Yield would be uncertain due to the combination of diseases that could affect these crops, and total annual production unpredictable. In the event that plants establish and crops are harvested, there would be further losses to quality further increasing uncertainty of production. The additional loss of **chlorothalonil** (£29M - 18%) would mean the post emergence disease control would also be compromised.

Loss of the four insecticide active substances, including the additional loss of **lambda-cyhalothrin** (£16M - 10%) would leave only pirimicarb for aphid control and esfenvalerate, alpha- and zeta-cypermethrin for other insect pest control. Losses in quality and production in combining pea and field bean would be high due to pea moth, pea and bean weevil, bruchid beetle and pea midge attacks. There would be an increased risk of resistance in aphid populations to pirimicarb.

Conclusion

The three scenarios provide different challenges to the crop. In scenario 1, resistance management would become more difficult due to the loss of **iprodione** and **thiacloprid**, leaving a single active ingredient for disease and pest control in some cases. Loss of **linuron** would cause poor weed control and difficult harvest conditions, whilst high weed seed return would put additional pressure on subsequent crops.

Scenario 2 would increase the likelihood of resistance to insecticides arising, causing greater likelihood of more significant impact on crop production. In this scenario, sustainability of crop production will be at high risk. In addition the loss of **propyzamide** poses a significant threat to blackgrass strategies in the UK, blackgrass control being the single largest threat to arable production in the East of England. Production of pulses would be threatened by the reduction in their value as a break crop.

Scenario 3 presents the greatest challenge, and under this scenario crop production would be unsustainable. This would lead to significant reduction of the area of peas and beans grown in the UK, and possibly a complete loss of these crops. The loss of key active substances would lead to poor establishment and weed control, and inability to control damaging insect pests. Forecast financial loss to the UK would be almost complete. In this

case there would be complete inability to export produce for human consumption, lower prices for produce, unpredictable yields and resultant job losses in this industry.

The UK is one of the largest producers of field beans in the EU and there is significant investment and employment in the associated processing industry that would be impacted by a significant reduction in area grown.

Potatoes

There are approximately 122,000 ha of potatoes grown in the GB, with an estimated farmgate value of £900M (Table 26).

Table 26 Summary of economic losses £M - based on yield loss only, in potatoes across the three scenarios of endocrine disrupting pesticide loss

		Potatoes
Crop area	**(ha)**	**122,000**
Production	**(t)**	**5,500,000**
Farm gate value	**(£M)**	**£900**
Scenario 1	Fungicides	**£3**
Scenario 1	Herbicides	**£52**
Scenario 1	Insecticides	**£0**
Scenario 1	All pesticides	**£56**
Scenario 2	Fungicides	**£3**
Scenario 2	Herbicides	**£189**
Scenario 2	Insecticides	**£0**
Scenario 2	All pesticides	**£193**
Scenario 3	Fungicides	**£5**
Scenario 3	Herbicides	**£189**
Scenario 3	Insecticides	**£1**
Scenario 3	PGR - storage	**£226**
Scenario 3	All pesticides	£421

Scenario 1 – Mancozeb, linuron, thiacloprid, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £56M – 6% reduction in farmgate value.

Loss of **mancozeb** would impact on the ability of potato growers to manage blight resistance. It is estimated that annual yield loss from moderate late blight is in the region of 7%, with a further 0.3%[9] due to losses in store with a lost yield potential of 400,000 tonnes (based on a crop area of 122,000 ha). Two active ingredients representing two chemical

[9] ADAS (2002) Testing the sustainability of stockless arable organic farming on a fertile soil. Defra OF0301

groups would be lost immediately with scenario 1 as these are available as co-formulations with mancozeb zoxamide, and benthiavalicarb). In the short term, it is likely that the use of other active ingredients will increase as will associated costs. Yield impacts from loss of mancozeb are limited in the short term as control can be provided by alternative chemistry. However, mancozeb is a key active ingredient in fungicide resistance management for late blight due to its multisite activity and no resistance to this product has been reported for late blight or other plant pathogens since its introduction in the 1960s. This is in contrast to several other late blight products, where reduced or loss of fungicide sensitivity has been identified in laboratory mutants or field isolates for *P. infestans* and/or other plant pathogenic fungi. Early blight (*Alternaria* spp.) is now considered a major problem for some growers and increased costs through loss of mancozeb would also incorporate the switch to alternative chemistry for the effective control of early blight, where products co-formulated with mancozeb and as tank mixes with mancozeb are extensively used for this. It is expected that production would remain unchanged (i.e. no loss of yield or value), however cost of production would increase. For control of both early and late blight this would require on average 4.4 spray applications to be replaced with more expensive chemistry equivalent to £8 extra per spray or £35.20 per ha, across 80% of the crop area, or £3.4M.

Linuron (£52M – 6%) is one of the most frequently used pre-emergence herbicides on the UK ware crop. Loss of this active would limit the pre- and post-emergence options in the crop. In mixture with metribuzin or prosulfocarb, linuron significantly increases the spectrum of weed species control particularly black bindweed and fat-hen. The withdrawal of linuron would increase the reliance on metribuzin, which could cause problems due to variety and soil type restrictions and prosulfocarb, pendimethalin and clomazone which have gaps in their spectrum of control. Withdrawal of this product will result in some reductions in yield (up to on affected crops 10%), and also incur some additional herbicide and cultural control costs.

Scenario 2 – Above plus metribuzin

The impact of the loss of active substances in scenario 2 is estimated to be a £193M – 21% reduction in farmgate value.

The loss of **metribuzin** (£137M – 15%) would cause significant problems with weed control in potato crops, particularly on organic soils where other residual herbicides are ineffective due to high levels of organic matter. Its loss along with linuron will compromise weed control in potatoes, leaving a wide range of weeds including fat-hen, pansy, pale persicaria, redshank and poppy with limited control. On organic soils control from herbicides would be

inadequate, with reliance on mechanical weed control which would increase costs by £30/ha[10]. On mineral soils other options including prosulfocarb, flufenacet, pendimethalin, clomazone, bentazone and rimsulfuron have some activity on selected weeds, but do not cover the full spectrum, with sulphonyl ureas affected by increasing resistance in some weeds, and bentazone a problem in some water catchments. These actives may also be tank-mixed with either linuron or metribuzin to achieve reliable control, so loss of either would have a knock on effect.

The loss of metribuzin alone and in combination with linuron could therefore cause large yield effects and increase harvesting problems, as well as increasing costs of trying to control weeds with more limited chemical options and cultural control methods particularly on organic soils. Yield losses could range from 14-80%[11], Orke & Dehne (2004) quoted an average yield loss of 39%[12] due to poor weed control. Yield impacts from weeds are very variable depending on soils and weather. Combined losses as a result of the withdrawal of both linuron and metribuzin are estimated at £189M – 21%, but could be higher in years that favour weed growth.

Scenario 3 – Above plus fluazinam, cymoxanil, mandipropamid, glufosinate ammonium, chlorpyrifos, lambda-cyhalothrin, chlorpropham

The impact of the loss of active substances in scenario 3 is estimated to be a £421M – 47% reduction in farmgate value.

Fluazinam, **cymoxanil** and **mandipropamid** were, after mancozeb, three of the most frequently applied fungicides in 2012. The ratings included on the Euroblight fungicide table indicate there would be a greater reliance on products with protectant rather than curative activity if cymoxanil were lost. Scenario 3 would result in the loss of 7 modes of action overall from the blight fungicide programme, with only one active ingredient with multisite activity (propamocarb-hydrochloride) remaining. This would have serious consequences for preventing fungicide resistance development in late blight as well as compromising control if curative activity is required. In the initial instance the impact is limited to a £5M – 1%

[10] Clayton R, Parker B, Ballingall M & Davies K (2008) Impact of reduced pesticide availability on control of Potato cyst nematodes and weeds in potato crops. http://www.potato.org.uk/sites/default/files/%5Bcurrent-page%3Aarg%3A%3F%5D/Reduced%20pesticide%20PCN%20case%20report%20Sept%2008_0.pdf

[11] Bond W. & Turner R (2005) Weed Management Outline for Potatoes. http://old.gardenorganic.org.uk/organicweeds/downloads/potato.pdf

[12] Oerke EC & Dehne HW (2004) Safeguarding production – losses in major crops and the role of crop production. Crop Protection, 275-285

reduction in value as the remaining actives would be able to control blight in the short term, al be it at higher cost to the grower. However, the impacts in future years would be greater as the ability to manage resistance in the blight population would be severely impacted as a result of the limited range of actives available. This will increase the likelihood of yield losses in the future.

The loss of **lambda-cyhalothrin** removes the most widely used insecticide on potatoes. While alternatives are available for the control of aphids, no alternatives exist for cutworms, beetles, weevils and caterpillars. Cutworm is considered a sporadic pest of potatoes and damage affects tuber quality more than yield, which in severe cases can result in crop rejection. However, potato is considered among the crop hosts least susceptible to cutworm attack. Furthermore, the early larval stages (1st and 2nd instars) suffer high levels of mortality during periods of heavy rainfall meaning that this pest is usually only a problem in dry years. While irrigation represents an alternative control measure, the loss of this active, along with **chlorpyrifos** and **cypermethrin**, would mean that no alternative chemical treatments are available for cutworm. However, due to its sporadic nature and the low susceptibility of potato, it is considered that untreated reductions in value would be £0.8M - 0.4%. Along with the loss of cypermethrin, no alternatives would be available for the control of other caterpillar pests, however these are not considered important pests of potato and damage is likely to be insignificant. Similarly, while no alternative active substances are available for beetles and weevils, these are not considered important problems either and untreated yield losses to these are also considered to be minimal.

Chlorpropham is a sprout suppressant for which there is no suitable alternative available to some businesses, particularly in the potato processing sector. Loss of chlorpropham will severely affect UK potato production reducing the value by £226M – 25%. The consequences of storage yield loss, particularly to the processing supply chain would result in closure of potato processing plants and loss of UK manufacturing jobs.

Conclusion

The two main issues are yield losses from difficulty in controlling weeds through loss of metribuzin (and to a lesser extent linuron) (£52M-£270M) and loss of chlorpropham, which could cause storage losses reducing the farmgate value of the crop by £226M – 25%.

Impacts from insecticide losses are relatively small in the short term with alternatives available at a similar cost. The main issue is the control of caterpillar and cutworm, both of which are intermittent problems with the total impact from yield impacts around £0.8M.

Losses of foliar fungicides on potatoes is unlikely to have a significant impact on yield in the short term, with alternative chemistry likely to maintain current yields but at increased cost

(£5M). . The loss of multi-site active substances such as mancozeb, as well as single site products with alternative modes of action (loss of 7 modes of action), will have consequences for the implementation of late blight resistance management strategies which will impact on yield in the longer term and on gross margins as well.

Sugar Beet

There are approximately 120,000 ha of sugar beet grown in the UK, with an estimated farmgate value of £224M (Table 27).

Table 27 Summary of economic losses £M - based on yield loss only, in sugar beet across the three scenarios of endocrine disrupting pesticide loss

Crop area	**(ha)**	**120,000**
Production	**(t)**	**8,000,000**
Farm gate value	**(£M)**	**£224**
Scenario 1	Fungicides	**£30**
Scenario 1	Herbicides	**£0**
Scenario 1	Insecticides	**£0**
Scenario 1	All pesticides	**£30**
Scenario 2	Fungicides	**£38**
Scenario 2	Herbicides	**£35**
Scenario 2	Insecticides	**£0**
Scenario 2	All pesticides	**£74**
Scenario 3	Fungicides	**£61**
Scenario 3	Herbicides	**£98**
Scenario 3	Insecticides	**£25**
Scenario 3	All pesticides	£184

Scenario 1 – Cyproconazole, epoxiconazole, cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £30M – 13% reduction in farmgate value.

Cyproconazole (£28M – 12%) has high usage in mixture particularly with trifloxystrobin. Offering broad spectrum control of the four main foliar diseases of sugar beet it forms the backbone of many fungicide programmes. Yield loss clearly varies year on year depending on prevailing disease and weather conditions, but estimated yield loss in a high disease year could be 25% or in a low pressure year less than 5%.

Scenario 2 – Above plus difenoconazole, propiconazole, tetraconazole, triademenol, carbetamide, propyzamide, triflusulfuron methyl, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £74M – 33% reduction in farmgate value.

The triazoles in this group still have a role in disease control, but due to the dominance of **cyproconazole** in the market their use has declined recently. The largest sector share after cyproconazole is probably taken by **difenoconazole** (£9M – 4%) which was applied to 26% of the treated area. Loss of both of these active substances would severely reduce the ability of growers to control foliar diseases.

Triflusulfuron-methyl (£35M – 16%) is the only sulfonylurea used in sugar beet production. It was applied to 79% of the treated area in 2013 and can be used up to four times per crop. It is particularly useful to control conventional volunteers of oilseed rape and brassica weeds, which can be very competitive, and many other species including a number of hard to control species. Loss of this active is estimated to reduce yield by 20% on the treated area.

Scenario 3 – Above plus carbendazim (expiry date October 2014), hymexazol, thiram, chlorpropham, ethofumesate, fluazifop-P-butyl, glufosinate ammonium, lenacil, tepraloxydim, beta-cyfluthrin, chlorpyrifos, clothianidin, lambda-cyhalothrin

The impact of the loss of active substances in scenario 3 is estimated to be a £184M – 82% reduction in farmgate value.

All sugar beet seed is steeped in **thiram** (£11M – 5%) prior to pelleting to protect against damping off diseases during emergence. Occurrence of these diseases will be favoured in warm wet seasons.

Loss of **ethofumesate** (£45M – 20%) will have a significant effect on weed control. A common component of tank mixes it has pre and post emergence uses and controls a broad-range of species. It offers good levels of blackgrass control pre-emergence and has the advantage of being a non ACCase herbicide. Other ACCase herbicides **fluazifop-p-butyl** and **tepraloxydim** (£12M – 5%) offer blackgrass control even in resistant situations and control of blackgrass needs to be at as high level as possible if it is to be controlled long-term, loss of these will therefore impact on the ability to control blackgrass in the rotation.

Pest control would also be impacted (£25M – 11%) as a result of the loss of **beta-cyfluthrin** and **clothianidin** for soil pests, with small reductions in value as a result of the loss of **chlorpyrifos** and **lambda-cyhalothrin**.

Conclusion

Disease control will become much more difficult without triazoles. Generally they are mixed with active substances such as strobilurins and have become well adopted within the crop. Where disease outbreaks occur losses can be severe and disease can spread rapidly. Fungicides can offer both curative and preventative properties, which make them especially useful tools to keep the canopy green for longer enhancing yield potential too. Longer campaigns into the winter months rely on green leaf material to provide early frost protection.

Weed control generally relies on tank mixes of active substances and **ethofumesate** has always featured strongly in these mixtures, having both contact and residual activity. Besides being a good tank mix partner, the activity of ethofumesate enhances the activity of other herbicides in the mixture. **Lenacil** will control oilseed rape.

Grass weeds are becoming more of a problem in sugar beet where it overlaps with wheat in the rotation. Beet can be seen to have a role as part of an integrated control strategy for blackgrass. Although resistance to the ACCase group of chemicals is high, useful control by herbicides such as **fluazifop-p-butyl** and **tepraloxydim** can still be achieved. Yield losses estimated at £13.2M for these products, but does not include losses in other crops since control of blackgrass should be considered a rotational issue and hence will affect all crops in the rotation.

Plant protection products applied to the seed have made a significant contribution to sugar beet cultivation protecting against fungi (**hymexazol** and **thiram**) and against soil pests (by **beta-cyfluthrin** and **clothianidin**). This has helped germination and establishment greatly.

Establishing an even population with good ground cover is key to maximising yield potential. Continued protection offered by these products through systemic action has safe-guarded the crop against virus infection via aphid transmission up to the 12 leaf stage. Virus infection was a significant cause of yield reductions in the past and with no varietal resistance to the viruses or aphids, and, with the high levels of resistance to foliar insecticides, loss of these active substances could see the return of virus yellows.

Hops and Vines

The total farmgate value of the hops and vines crop group is estimated at £21M per year (Table 28), with approximately 2,690 ha grown each year. The largest crop in terms of area grown and value is vines £12M with hops accounting for a further £9M (Table 28).

Table 28 Summary of economic losses £M - based on yield loss only, in hops and vines across the three scenarios of endocrine disrupting pesticide loss

		Hops	Vines	Hops and vines
Crop area	**(ha)**	**990**	**1,700**	**2,690**
Production	**(t)**	**1,350**	**na**	**1,350**
Farmgate value	**(£M)**	**£9**	**£12**	**£21**
Scenario 1	Fungicides	£2	£3	**£5**
Scenario 1	Herbicides	£0	£0	**£0**
Scenario 1	Insecticides	£2	£0	**£2**
Scenario 1	All pesticides	£4	£3	**£7**
Scenario 2	Fungicides	£4	£3	**£7**
Scenario 2	Herbicides	£0	£3	**£3**
Scenario 2	Insecticides	£4	£0	**£4**
Scenario 2	All pesticides	£8	£5	**£14**
Scenario 3	Fungicides	£7	£8	**£15**
Scenario 3	Herbicides	£1	£6	**£6**
Scenario 3	Insecticides	£11	£1	**£12**
Scenario 3	All pesticides	£19	£15	£33

CL – Complete loss

Hops

There are approximately 990 ha of hops grown in the UK, with an estimated farmgate value of £21M.

Scenario 1 – Myclobutanil, abamectin

The impact of the loss of active substances in scenario 1 is estimated to be a £4M – 44% reduction in farmgate value.

Myclobutanil (£2M – 22%) is the backbone of hops fungicide programmes and one of only a few permissible for exported crops. Hop powdery mildew is well renowned for mutating, which is why growers always use fungicides in pairs, never alone. The loss of myclobutanil would reduce choice to five active substances, increase pressure on the other two DMI's, and leave growers with no active substances (except bicarb) for the last 4 weeks of crop development for crops being exported to the USA.

Abamectin (£2M – 22%) is the only effective acaricide, and natural predators simply can't keep up with the two-spotted spider mite in hops. Total crop loss at least one year in four = £9M. With no reliable way to control spider mites, most growers could only take one partial crop loss before leaving the crop, never to return.

Scenario 2 – Above plus bupirimate, penconazole, propyzamide, deltamethrin

The impact of the loss of active substances in scenario 2 is estimated to be a £9M – 100% reduction in farmgate value. Complete loss of the industry.

The loss of fungicides (**bupirimate** £1M – 11% and **penconazole** £1M – 11%) against powdery mildew will make it impossible to grow anything but tolerant varieties. With the added pressure of being without any tools to control either spider mite or novel pests (**deltamethrin** - £2M – 22%) like flea beetle and caterpillars, all of which can destroy entire crops within weeks, hop production will become erratic and unpredictable. Together, these will cause further decline in UK hop growing, a decline that will drive half the growers out of business within 5 years.

Scenario 3 – Above plus cymoxanil, mandipropamid, fluazifop-P-butyl, lambda-cyhalothrin, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £421M – 47% reduction in farmgate value.

This scenario leads to the complete loss of fungicides for downy mildew control (**cymoxanil,** £2M – 22% and **mandipropamid,** £1M – 11%**)**. It is expected that half the varieties would suffer 50% annual yield loss whilst the remainder would suffer 25% annual yield loss. Additional loss of **lambda-cyhalothrin** (£2M – 22%) and **spirotetramat** (£5M – 56%) leaves no control against flea beetle and caterpillars or aphids. Damson hop aphids would be expected to cause complete crop loss three years in five.

The loss of either the fungicides or the insecticides would be completely devastating for the crop, the combined loss is expected to mean that commercial hop production in the UK would not be viable.

Conclusion

It is very important to note that British Hops is a long established niche crop for beer flavouring, standing apart from the commodity hop crop that is alpha-acid for bittering. As such, British hops are highly prized and brewers pay premium prices for continuing high quality. This is under-pinned by high standards of crop grading, which are upheld very strictly, and surprisingly low levels of crop damage from pest and disease can render a whole crop unsalable. This has always been the case, and everyone in the crop is acutely aware how very small infestations of mildew (either from disease or aphids) can produce enough aflotoxins to risk affecting brewer's yeast. There is simply no place for anything other than high quality produce, and any estimate of economic farm-gate loss does nothing to account for the reduction in confidence for continuity of supply so crucial to our brewer customers, to whom hops are a crucial yet very small part of their overall costs.

In the absence of suitable alternative approvals Scenario 1 removing **abamectin** and **myclobutanil** would leave British hop growers with no reliable acaricide, and limit the choice of effective fungicides further.

The loss of **bupirimate** and **penconazole**, in Scenario 2, would remove varieties susceptible to powdery mildew. And the loss of **deltamethrin** would increase the incidence of total crop failures from novel pests like flea beetle, capsids and caterpillars, which have all been causing more issues in recent years.

With Scenario 3, the loss of **spirotetramat** alone would be enough to predict that there would be no commercial hop growing in the UK at all within five years, such is the voracity of the damson hop aphid and its ability to destroy entire crops.

British Hops occupy a tiny acreage of less than 1000 hectares, but without them there would be no British beer, and a number of sizeable UK breweries have founded their businesses on recipes using the Great British hop. Hops in themselves are labour intensive and difficult to grow, and only needed in small quantities, which is why there are so few growers anywhere. But hops are celebrated by brewers across the world, especially in the recent resurgence in the beer market. The value of hops to the economy is not so much their farm-gate value (£9 million in UK), but more the fact that beer cannot be brewed without them. The contribution of brewing to the economy, on the other hand, is about a thousand times the value of the hops they use (being about £19 **billion** in the UK).

Vines

There are approximately 1,700 ha of vines grown in the UK, with an estimated farmgate value of £12M.

Five year average 2.5m bottles, estimated from the 2013 vintage at 4m bottles sparkling and 1m bottles still wine, increasing significantly in 2015. Each bottle of sparkling pays currently £3.25/bottle duty, still £2.05/bottle duty plus VAT at 20% when sold in the UK.

Scenario 1 – Fenbuconazole, iprodione, mancozeb, myclobutanil, tebuconazole

The impact of the loss of active substances in scenario 1 is estimated to be a £3M – 23% reduction in farmgate value.

The loss of **mancozeb** (£1M - 8%) would be disappointing for UK viticulturists as it is one of two approved products proven to give some control of certain trunk diseases, it is used in season to protect against downy mildew infection. However label changes during re-

registration have mitigated against extensive use of this product in programmes, so in many spray programmes product substitution has occurred.

The loss of all the approved triazoles (£0.5M – 5%) for use on vines will be problematic when creating an anti-resistance strategy for powdery mildew. The crop does just about have enough varied chemistry to formulate a powdery mildew anti-resistance strategy but should QoI resistance occur this strategy will fail due to lack of alternative products.

Powdery mildew is a major disease of vines in the UK in part because a high proportion of the grapes grown are used for sparkling wine production using the highly mildew susceptible and late harvested cultivars Pinot Noir and Chardonnay. The loss of the triazoles would therefore have a considerable impact on the production of grapes from these cultivars as in periods when the powdery mildew risk is high i.e. July and early August this group offers not only protection against infection, but also some eradicant action against existing infection and are less rain sensitive post use that potassium bicarbonate (AgriKarb).

Late season botrytis control for grapes grown in the UK is difficult given the temperate climate and can write off the crop if uncontrolled. **Iprodione** (£1M – 8%) has been shown to be the only effective active substance in gaining some control of late season botrytis.

There is now a potential replacement for iprodione for botrytis control in vines close to harvest fenpyrazamine MAPP 16607 recently gained approval and will be marketed in the UK in autumn 2014, it has a 14 day harvest interval the same as iprodione, but only 1 application is permitted/year. It is a new fungicide group, which will also help as regards avoiding resistance. However it still leaves growers very limited in products for use close to harvest i.e. just replacing iprodione with fenpyrazamine the introduction of this new fungicide reduces the impact of iprodione loss.

Scenario 2 – Above plus propyzamide

The impact of the loss of active substances in scenario 2 is estimated to be a £5M – 44% reduction in farmgate value.

Propyzamide (£5M – 21%) is one of two UK approved and available residual herbicides that can be used on vines in the cropping year, it is particularly useful as unlike isoxaben it can provide pre and post emergence control of grass weeds including volunteer cereals. The main impact of this loss will actually be in increased costs associated with additional applications of contact herbicides, not captured within these figures.

Scenario 3 – Above plus cymoxanil, fosetyl aluminium, glufosinate ammonium, lambda-cyhalothrin, spinosad, spirotetramat

The impact of the loss of active substances in scenario 3 is estimated to be a £12M – 100% reduction in farmgate value, most growers would cease production.

Downy mildew is one of three major disease of vines (the others being botrytis and powdery mildew), experience from mainland Europe indicates a resistance management policy needs to be adhered too or the disease will quickly become resistant to fungicides.

The loss of **cymoxanil** (£3M – 21%) would also be a great loss as unlike the other fungicides for downy mildew control it has a relatively short i.e. 14 day harvest interval, so is particularly useful for application close to harvest. The loss of fenomenal (only available in mixture with **fosetyl aluminium**) for downy mildew control would also be a blow as the use of this fungicide has been found to be particularly useful as a protectant eradicant used in late July-August as weather conditions often become particularly conducive to this disease.

The control of Powdery Mildew is possible given the products available, but withdrawing all the Triazoles means that substitution needs to occur by another mode of action group.

Losing **glufosinate ammonium** (£3M – 25%) will leave growers with one application of glyphosate and two of carfentrazone-ethyl (being the only approved contact herbicides) with isoxaben as the only residual weed killer (which on its own isn't very effective). This very limited selection is deemed not sufficient for the crop which is expanding.

Spinosad and **spirotetramat** approvals are relatively new to vines, the approvals were granted respectively for the control of Spotted Winged Drosophila, SWD, (and caterpillars) and assist with Phylloxera control. Loss of these actives could increase the risk of SPD becoming established in the crop.

The loss of **lambda-cyhalothrin** (£1M – 8%) for general insect control could be tolerated if there was a direct replacement but most of the direct replacements are listed as under threat e.g. deltamethrin.

Conclusions

The combination of the above scenarios leaves the vine crop bereft of virtually all herbicides, insecticides and downy and powdery mildew control agents, plus lacking short harvest interval products at a critical point in the growing cycle. These scenarios if fully enacted would drive production costs upwards and due to the more frequent spray regime environmental impact maybe greater, certainly labour costs will be higher.

Higher production costs and losses due to products being withdrawn will not encourage new entrants to the crop and the commercial viability of existing businesses will be under threat.

Whilst the vine crop could cope just with Scenario 1 and 2 for grapes scenario 3 is expected to cause growers to cease production.

Forestry

There are approximately 3,127,000 ha of forestry grown in the UK, with an estimated forestgate value of £404M (Table 29).

Table 29 Summary of economic losses £M - based on yield loss only, in forestry across the three scenarios of endocrine disrupting pesticide loss

		Forestry
Crop area	**(ha)**	**3,127,000**
Production	**(t)**	**10,616,000**
Farm gate value	**(£M)**	**£404**
Scenario 1	Fungicides	**£0**
Scenario 1	Herbicides	**£0**
Scenario 1	Insecticides	**£6**
Scenario 1	All pesticides	**£6**
Scenario 2	Fungicides	**£0**
Scenario 2	Herbicides	**£1**
Scenario 2	Insecticides	**£6**
Scenario 2	All pesticides	**£7**
Scenario 3	Fungicides	**£0**
Scenario 3	Herbicides	**£1**
Scenario 3	Insecticides	**£6**
Scenario 3	All pesticides	£7

Scenario 1 – Cypermethrin

The impact of the loss of active substances in scenario 1 is estimated to be a £6M – 1% reduction in farmgate value.

Hylobius abietis can lead to complete loss of newly planted native deciduous or coniferous species, in some cases making continued forest management unsustainable. The use of **alpha cypermethrin** or **cypermethrin** is, in many cases, currently the only economically, environmentally, socially and technically feasible way of preventing this damage. If not controlled it would be difficult to establish the next crop of trees on many sites.

Scenario 2 – Above plus propyzamide

The impact of the loss of active substances in scenario 1 is estimated to be a £7M – 2% reduction in farmgate value.

Propyzamide is the second most important herbicide of choice for grass control during the first two years of establishment of new or replanted woodlands.

Scenario 3 – No additional losses

Conclusion

The UK currently uses around 30 million tonnes timber and wood products annually of which circa 10 million tonnes is produced in the UK and 20 million tonnes of imports.

The industry employs 43,000 people^ – much of which is in areas of low employment opportunities.

Cypermethrin and **propyzamide** are highly important tools used to economically assist the establishment of UK forests.

The most widely grown and valuable commercial species, Sitka Spruce, is largely grown in relatively hostile upland areas of low employment where the use of crop protection products such as cypermethrin and propyzamide can be critical to the crop establishment process.

Any reduction in the number of critical tools used to establish our future timber requirements will have an immediate effect on employment, and a longer term effect on our timber security.