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Time and Cost of New Agrochemical Product Discovery, Development and Registration

A Study on Behalf of Crop Life International

RESULTS FEBRUARY 2024

AgbioInvestor

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2022

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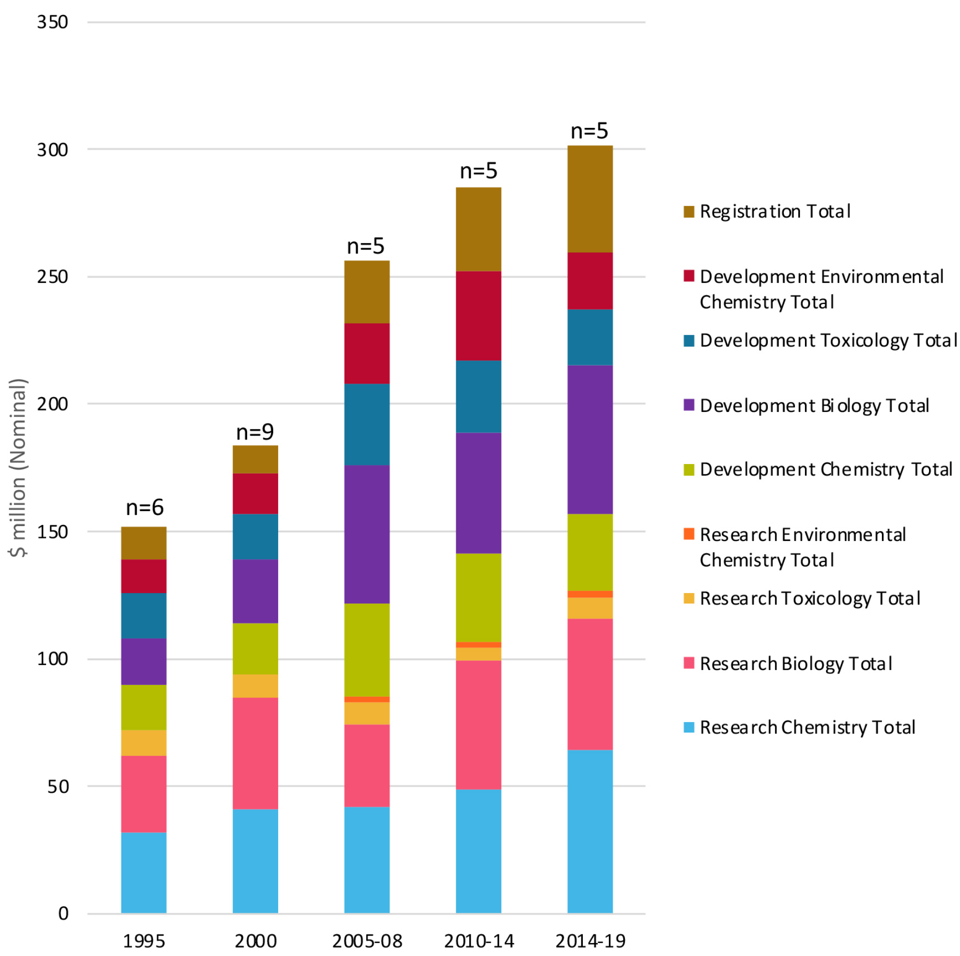
Executive Summary: The Cost to Bring a New Active Ingredient to the Market

This study presents the results of a survey of the leading crop protection companies designed to determine:

- The expenditure necessary for discovering and developing a new crop protection AI in 1995, 2000 and in the 2005 to 2008, 2010 to 2014 and 2014 to 2019 periods, in nominal terms.
- The average time between initial synthesis and launch.
- Nominal costs associated with obtaining and maintaining a CODEX MRL (new active, additional/new use and periodic review) in the 2014 - 2019 time frame.
- Nominal costs associated with the re-registration (including fees, studies etc.) of an AI that was re-registered in the 2014 - 2019 time frame.

Five companies were surveyed for the period 2014-2019, and the results were as follows:

Discovery & Development Costs of a New Active Ingredient (Mean Average)



n = the number of survey responses

Executive Summary: The Cost to Bring a New Active Ingredient to the Market

The overall costs of the discovery and development of a new crop protection AI increased by 21.1% from $152 million (€115 million) in 1995, to reach $184 million (€140 million) in 2000. From 2000 to the 2005-08 period, costs increased by 39.1% to $256 million (€189 million). From 2005-08 to the 2010-14 period, costs further rose by 11.7% to $286 million (€215 million). The latest survey indicated that the costs associated with bringing a new active ingredient to the major US and European markets had increased by 5.7% to $301 million (€261 million).

The survey results demonstrated that the average cost of new AI research rose by 30.6% from $72 million per AI in 1995 to $94 million in 2000, but declined slightly to $85 million in 2005-08, attributed to cost savings potentially made due to greater efficiency from high throughput screening, combinatorial chemistry and genomics, however, between 2005-08 and 2010-14 the cost of research of a new agrochemical increased by 25.9% to $107 million The 2014-19 survey results indicate that research expenditure increased by a further 18.9% to $127 million In contrast with the development phase, chemistry (+31.6%) and toxicological and environmental chemistry (+58.4%) costs increased, whilst biology (screening and small trials) costs increased marginally (+1.4%).

The survey results demonstrated that the average cost of taking an AI through development stages increased from $67 million in 1995 by 17.9% to $79 million in 2000, by 84.8% to $146 million by 2005-08 period and remained at that level in the 2010-14 period. The latest survey indicated that AI development costs had fallen 8.5% in the 2014-19 cycle to $133 million Within this, the cost of field trials increased by 23.9%, whilst development costs associated with chemistry (-13.9%), toxicology (-23.4%) and environmental chemistry (-35.4%) all declined.

The 2014-19 survey results indicate a migration of toxicological and environmental chemistry costs from the developmental phase to the research phase. This likely indicates the companies' response to increased regulatory pressure within the major crop protection markets regarding AI fate and metabolites, meaning that toxicological and environmental chemistry profiling is a more significant factor in the decision to progress an AI from the research phase into development.

Executive Summary: The Cost to Bring a New Active Ingredient to the Market

Between 2010-14 and 2014-19, the average cost of chemistry (synthesis and formulation) in the research phase rose by 31.6% to $64 million making this the largest single cost in the R&D of a new agrochemical. The next largest cost is field trials (large scale and registrations) in the development phase, up by 23.9% to $58 million, both sectors now exceed the cost of biology (screening) in the research phase, the single largest R&D cost in the previous survey. Biology (screening) expenditure increased by 1.4% to $52 million

The 2014-19 survey indicates that average registration costs have increased by 25.9% to $42 million, representing 13.9% of the overall costs associated with bringing a new active ingredient to market, meaning the cost of registration is at the highest level as a proportion of overall costs since the beginning of this series. Registration costs have increased both in absolute terms and as a proportion of overall costs since the first edition of this survey, rising from an average of $13 million in 1995 at 8.6% of the overall costs. In overall terms, registration costs have more than tripled.

While costs have steadily increased, the survey results also demonstrated that the average lead time between the first synthesis of a new crop protection molecule and its subsequent commercial introduction has now also increased to over 12 years. This increase could reflect greater complexity in the data requirements of regulatory bodies. Another potential contributing factor could be that regulatory bodies refrain from granting conditional approvals.

Crop Protection AI Discovery and Development Lead Time

	1995	2000	2005-08	2010-2014	2014-19
Number of years between the first synthesis and the first sale of product containing AI	8.3	9.1	9.8	11.3	12.3

Executive Summary: Breakdown of Expenditure Devoted to the R&D Process 2019

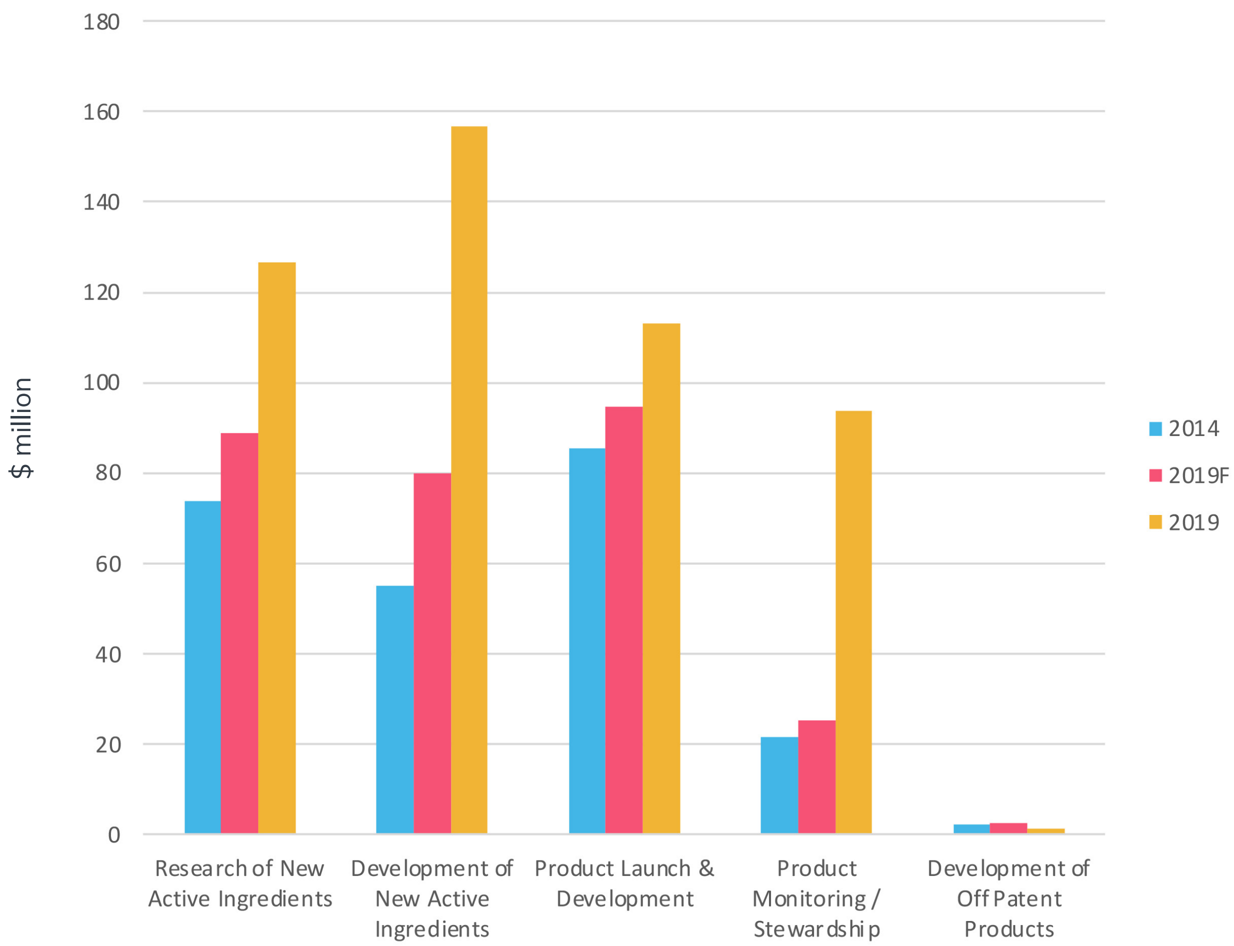
Breakdown of Expenditure Devoted to the R&D Process 2019

This study presents the results of a survey of the leading crop protection companies in order to determine:

- The overall level of expenditure devoted by the agrochemical industry to the research and development process.
- The proportion of the R&D budget that is targeted at new AI discovery, development and managing the existing business, including product stewardship and monitoring.
- Changes in R&D expenditure between 2014 and 2019.

Responses to the survey were received from four companies.

Comparison of Average R&D Expenditure Breakdown of the Participating Companies

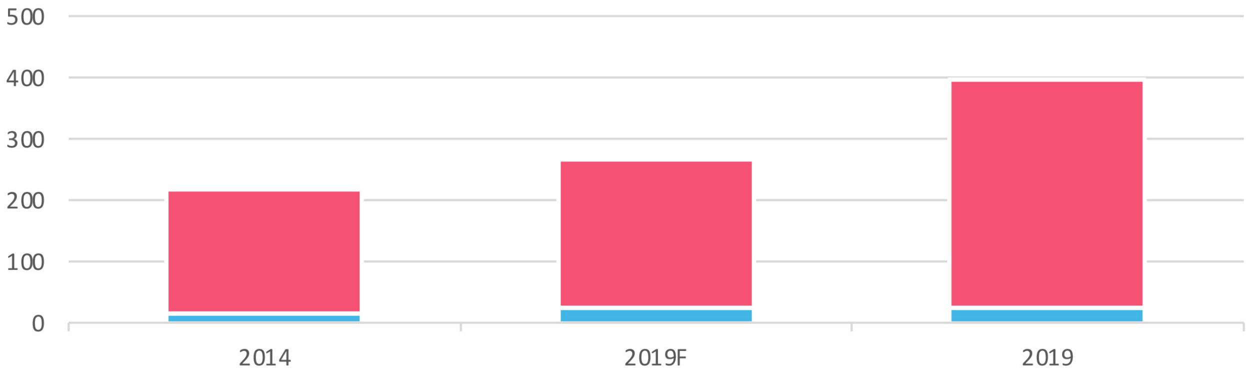


Executive Summary: Breakdown of Expenditure Devoted to the R&D Process 2019

From the previous edition of the survey, the participants expected R&D expenditure to increase across all sectors between 2014 and 2019, with the largest growth in expenditure expected in the area of development of new AIs (+44.7%), followed by research of new AIs (+20.6%) and then product monitoring and stewardship (+17.6%).

Comparisons of the expected R&D budget in 2019 (from the last iteration of this study) with the realised breakdown of 2019 R&D budgets indicate that research of new AIs, product launch and development costs and development of off-patent products account for a smaller share of the overall budget than was anticipated, but that development of new AI costs and product monitoring and stewardship costs account for more than anticipated.

Respondents were also asked to provide a breakdown of R&D costs between chemical and biocontrol products (all the R&D criteria above except product monitoring and stewardship). In 2014, the sum of the eleven participating companies' budgets was $2.387 billion, with this figure expected to increase by 22.6% to reach $2.927 billion in 2019. In reality, the average company budget increased by 82.7% from an average of $217 million in 2014 to $396 million.



Agrochemical Industry R&D Expenditure by Sector

Sector	2014		2019F		2019	
	$ million	% Share	$ million	% Share	$ million	% Share
Biological CP	16	7.3%	24	9.2%	26	6.6%
Chemical CP	201	92.7%	242	90.8%	370	93.4%
Total ($ million)	**217**		**266**		**396**	

Executive Summary: Breakdown of Expenditure Devoted to the R&D Process 2019

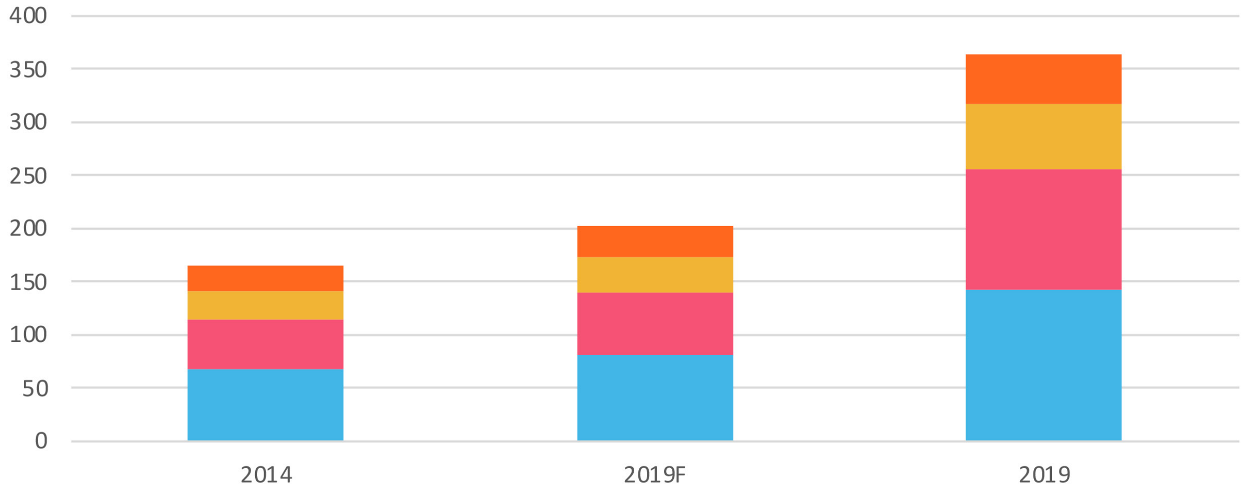
In 2014, chemical products accounted for 92.7% of the R&D budget at $201 million, with expenditure expected to rise by 20.1% to $242 million by 2019. The R&D budget for biological crop protection products, whilst only 7.3% of the total in 2014 at $16 million, was expected to rise by 54.6% to $24 million by 2019, accounting for 9.2% of the total. However, in reality, R&D expenditure attributed to chemical products increased by more than 84% in 2019, reaching $370 million, representing 93.4% of the total budget. The budget attributed to biological crop protection products also increased by almost 65% to $26 million in 2019, however, accounted for a lesser share of the overall budget than anticipated.

Respondents were also asked to provide a breakdown of development and stewardship costs by region (all the R&D criteria above except research of new AIs), focussing on where products in development were targeted. In 2014, the sum of the participating companies' development budget was $1,814 million and was expected to rise by 22.8% to $2,228 million by 2019. In reality, this figure increased by 79.4% from an average company expenditure of $165 million in 2014 to $363 million in 2019.

Europe accounted for the largest share of the development budget in 2014 at 41.1%, although this share was expected to fall to 40.1% by 2019, whilst the proportion of the budget focussed towards the Central and South American market was also expected to decline from 14.9% to 14.6%. In reality, the figure for Europe fell to 39.1% whilst the figure for Central and South America fell to 13.0%.

Conversely, the proportion of R&D budgets focussed on the North American market was expected to increase from 28.3% to 29.0%, with the figure in the Rest of the World region (RoW) expected to increase from 15.7% to 16.3%. In reality, expectations were exceeded for both of these regions, with 31.3% and 16.7% of budgets attributed to the regions, respectively. In nominal terms, the average company expenditure in each region increased over expectations.

Executive Summary: Breakdown of Expenditure Devoted to the R&D Process 2019



Agrochemical Industry R&D Expenditure by Region of the Participating Companies						
Sector	2014		2019F		2019	
	$ million	% Share	$ million	% Share	$ million	% Share
Europe	68	41.1%	81	40.1%	142	39.1%
North America	47	28.3%	59	29.0%	114	31.3%
RoW	26	15.7%	33	16.3%	61	16.7%
Central & South America	25	14.9%	30	14.6%	47	13.0%
Total ($ million)	**165**		**203**		**363**	

Executive Summary: CODEX MRL Costs

CODEX MRL Costs 2014-19

Responses to the survey were received from four companies. The average total cost of obtaining a CODEX maximum residue limit was $164,000, with the average cost of submissions per additional use valued at $66,000 and the average cost of periodic reviews at $153,000 (± 120,351). Inter-company variability was largest for costs associated with periodic review of CODEX MRLs, followed by costs of submission for additional uses and costs of obtaining a CODEX MRL for a new AI.

CODEX MRL Costs		
Currency	**$ million**	**€ million**
New AI	0.164	0.142
Per Additional Use	0.066	0.057
Periodic Review	0.153	0.132

Executive Summary: Re-registration Costs

Re-registration Costs

Re-registration costs were highest in the EU at $17.4 million, almost 7 times higher than re-registration costs in the US ($2.5 million) and more than 9 times higher than re-registration costs in other jurisdictions. The higher costs associated with re-registration in the EU is likely a result of the more resource intensive regulatory landscape that exists in this jurisdiction. For example, some participants indicated that they only tracked re-registration costs in the EU as data generated through the European application process is sufficient to support applications in other jurisdictions.

The survey results indicated that there was no significant relation between product type and costs associated with re-registration.

Costs Associated with Re-registering an AI Between 2014 and 2019

	Category	$ million	€ million	No. Responses
Geography	EU	17.4	15.1	3
	US	2.5	2.1	2
	Other	1.9	1.6	1
Item	Herbicide	9.5	8.2	2
	Insecticide	8.8	7.6	3
	Fungicide	13.9	12.0	1

Section 1: The Cost to Bring a New Active Ingredient to the Market

Section: 1

Introduction & Study Definitions

During 2023, on behalf of CropLife International, AgbioInvestor undertook a survey of the leading global agrochemical companies designed to provide information on the comparative costs involved in the discovery, development and registration of a new conventional chemical crop protection AI.

This study was carried out to update previously published information, which showed that the overall level of expenditure required to develop and register a new crop protection AI had grown from Deustche Mark 50 million ($23.1 million) in the 1975-1980 period to Deustche Mark 250 million ($157 million) for the 1990-1995 time frame (see Appendix 1). This study was updated in 2003, 2009 and in 2015 with the composite results seen in Appendix 2.

Study Definitions

The process leading to the discovery, development and commercialisation of a new agrochemical molecule is complex, costly and time consuming. The overall process can be split into three main stages, firstly the research programme leading to the discovery of a new molecule, secondly its development and lastly its registration with the appropriate regulatory authority.

Research

For a new chemical crop protection AI, the discovery or research process involves the synthesis of candidate molecules. These candidate molecules are subsequently subjected to a series of biological research tests or screens which are designed to demonstrate the biological activity of the new molecule. The screening process is likely to involve a number of increasingly complex stages to ensure that the new chemical has a suitable biological activity to merit further development. Although the synthetic and biological screening programme will lead to the discovery of molecules whose biological activity has been quantified, the decision as to whether the new chemical is suitable for full development will also involve other criteria, namely, it must be able to be patented, possess good toxicological and environmental properties and displays good commercial prospects.

Section: 1

Introduction & Study Definitions

Introduction

In order to satisfy these latter criteria, the research process generally includes preliminary toxicological and environmental testing as well as undertaking an evaluation of the new chemical's commercial prospects. Individual companies will set their own measure for success for these tests.

In previous years, the chemical synthesis stage has been enhanced through the development of combinatorial chemical methods, which have resulted in companies having the ability to synthesise large numbers of molecules, however, this procedure has now lost popularity. Similarly, the development of high throughput screening methods has enabled a greater number of molecules to be subjected to the biological research process. Biological research has also been enhanced through the use of genomics as a means for the discovery of new active molecules and potential sites of activity within target organisms.

Overall, the ultimate goal of the discovery process is to provide product leads or candidates with biological, chemical, toxicological, environmental and commercial characteristics suitable for further development.

Development

Agrochemical product development encompasses a broad range of processes which by definition are all aimed at developing the AI for subsequent commercialisation.
An important area of chemistry development is formulation evaluation. This generally involves testing and optimising various formulations of the new crop protection product to ensure that the AI can be delivered safely and effectively for subsequent field use.
Chemical development processes include the establishment of a pilot plant to produce suitable quantities of material for further biological and safety testing. Studies on optimising the manufacturing process for commercial production are subsequently undertaken with the aim of arriving at a suitably cost-effective manufacturing process.

Section: 1

Introduction & Study Definitions

In the research stage, biological screens, normally conducted in the laboratory, will have established that an AI has potentially important crop protection activity. Further biological development of the new crop protection AI is designed to investigate the activity of the AI against a variety of target pests, weeds or diseases in a number of crops under a variety of environmental situations. These studies are conducted in actual field situations and comprise both small and large-scale field trials. As well as testing the relative efficacy of the new AI, these field trials also encompass formulation evaluation and are used as a basis for the determination of the fate of the molecule and its metabolites or residues in the environment, soil and plants.

Although some preliminary safety testing will have been undertaken at the research stage, the development programme for a new crop protection AI includes significantly expanded toxicology and environmental chemistry testing to meet the statutory requirements of the regulatory bodies in the USA and the EU. The information generated from the regulatory process in these geographies is generally then used to fulfil regulatory requirements in alternative geographies.

Registration

The results of the developmental studies are subsequently submitted to the regulatory body for review. On acceptance, the AI is registered by the regulatory body, and commercialisation of the new crop protection product can then occur.

The following page contains a glossary of the main terms used in describing the research, development and registration process for a new crop protection AI.

Section: 1 Glossary of Terms

Glossary of Terms	
Term	**Definition**
Research	The discovery of new active ingredients, either from natural sources or by chemical synthesis, and subsequent screening to assess biological activity. Research stages generally also include preliminary toxicological and environmental testing before making the decision as to whether to progress the AI to full development.
Chemistry	The production of new chemical entities for assessment as potential active ingredients, either by conventional chemical synthesis that has now been enhanced by combinatorial chemistry techniques, or by extraction from natural sources.
Biology	Assessment of the biological efficacy of a potential new active ingredient. Conventional screening has now been enhanced by rapid throughput techniques. Biological Research has also expanded to cover Genomics.
Chemical Synthesis	Production of new potential active ingredients from basic chemical entities, this process is now enhanced by combinatorial chemistry.
Combinational Chemistry	A rapid mechanised system for the production of a large number of potentially active ingredients from basic chemical reagents.
High Throughput Screening	Rapid, mechanised system for assessing the biological activity of very low volumes of chemical.
Genomics	The application of biotechnology to further understand genetic structure and function.

Section: 1 Glossary of Terms

Glossary of Terms	
Term	**Definition**
Development	The progression of selected potential AIs from discovery to commercialisation. Includes regulatory studies required to support active ingredient and crop protection product registration as well as investigating the biological efficacy of the product in the field against a variety of pests in multiple crops, the manufacturing processes and formulation chemistry.
Chemistry	The scale up of chemical synthesis to produce volumes required for product development and then for commercial introduction. Also the development of formulations suited to the target crop applications.
Field Trials	The assessment of activity against target weeds / pests / diseases in the field, including comparison with standard treatments already on the market.
Toxicology	Safety assessment of the product candidate in biological systems.
Environmental Chemistry	Investigation of the physical and metabolic breakdown of a potential product in plant, animal, soil and water systems. Identification and assessment of the residues of the compound and its breakdown products in these systems.
Registration	Preparation and submission of data dossiers to, and subsequent negotiations with, registration authorities with the aim of obtaining approval to market a new product.

Section: 1

Study Scope & Methodology

Study Scope

As described above, the primary aim of this study was to determine the cost of several key parameters in the discovery and development process for a new crop protection product in the USA and the EU. The parameters to be investigated were

- Cost of discovery, development and registration
- The lead time between the first synthesis of the AI and the commercial introduction of the new active ingredient containing the AI.

Methodology

The study was conducted during 2023 according to the protocol included in Appendix 3.

The primary data for this investigation was obtained from a questionnaire (see Appendix 4), which was sent to a group of agrochemical companies that were considered to have active discovery programmes for conventional chemical crop protection products.

The industry has undergone significant consolidation through various merger and acquisition (M&A) events, notably the DowDuPont merger, which was announced in 2015 and from which Corteva Agriscience was spun out in 2018, and Bayer's acquisition of Monsanto in 2018. Consequently, the number of participating companies has fallen from previous editions of the survey.

Section: 1

Study Scope & Methodology

The companies included in this survey were:

- BASF Agricultural Solutions
- Bayer Crop Science
- Corteva
- FMC
- Syngenta

On receipt, the results of each company response were added to a matrix in which each company was listed by code number. Each company result was subsequently aggregated, and the mean value of each particular category was calculated. The results of the responses are shown in the report as mean values however, the variance within the actual responses is documented. In the case of Part 1 of the study, namely the evaluation of the cost of new product discovery and development, where a company response contained incomplete information on subcategories, the mean values were calculated on a pro rata basis to ensure that the mean category totals agreed with the subcategory values.

Average Exchange Rate to the US Dollar (2014-2019):

Dollar = 0.865 €

The results of each company, in US dollar terms, were subsequently aggregated so that a collective total was produced to represent the overall agrochemical industry.

Section: 1

Study Results 1995

Study Results

Cost of New Product Discovery and Development – 1995

Of the ten companies surveyed, data on six companies with respect to the 1995 situation for the cost of discovering and developing a new crop protection product were received. In some cases, the company responses did not contain information on all subcategories. As a result, subcategory mean values were calculated on a pro rata basis according to the number of responses received.

The actual number of responses and the mean values of the company responses are shown in the table below:

Discovery and Development Costs of a New Crop Protection Product (1995)

Category	Subcategory	Cost ($million)	Number of Responses
Research	Chemistry	32	5
Research	Biology	30	5
Research	Toxicology/Environmental Chemistry	10	5
Research	**Research total**	**72**	**6**
Development	Chemistry	18	6
Development	Field Trials	18	6
Development	Toxicology	18	6
Development	Environmental Chemistry	13	6
Development	**Development total**	**67**	**6**
Registration		**13**	**5**
Total		**152**	**6**

Section: 1

Study Results 1995

In terms of total costs of new product discovery and development, the results of the survey were essentially identical to the previous investigation (see Appendix 1), where the costs were shown to be DM 250 million ($157 million).

Overall, in 1995, the highest costs associated with new crop protection product R&D were in the research process leading to the discovery of a new product, with an overall cost of $72 million. Within this chemical synthesis was the most costly stage in the discovery process with an average value of $32 million followed by biological research screening with a mean cost of $30 million.

Total development costs in 1995 were found to be $67 million and these were relatively equally split amongst the various subcategories. The remaining expenditure deemed necessary for new product discovery and development comprised $13 million for product registration.

Section: 1

Study Results 2000

Cost of New Product Discovery and Development - 2000

In total ten companies were surveyed. All companies responded to the questionnaire with nine companies returning responses containing quantitative data.

As with the 1995 data, some company responses were incomplete in that they did not contain information on all subcategories and as a result subcategory mean values were calculated on a pro rata basis.

The actual number of responses for each category and subcategory, and the mean values of the company responses are shown in the following table:

Discovery and Development Costs of a New Crop Protection Product (2000)

Category	Subcategory	Cost ($million)	Number of Responses
Research	Chemistry	41	6
Research	Biology	44	6
Research	Toxicology/Environmental Chemistry	9	6
Research	**Research total**	**94**	**9**
Development	Chemistry	20	8
Development	Field Trials	25	8
Development	Toxicology	18	8
Development	Environmental Chemistry	16	8
Development	**Development total**	**79**	**8**
Registration		**11**	**7**
Total		**184**	**9**

Section: 1

Study Results 2000

The above results demonstrated that the overall costs for the discovery and development of a new agrochemical product in 2000 had risen to $184 million (€140 million).

As with the 1995 results, product research or discovery remained the most significant category in new agrochemical R&D with an expenditure of $94 million, equivalent to 51.1% of the total. Within this, biological screening was the most significant subcategory representing an expenditure of $44 million followed by new product chemistry which accounted for a further $41 million during 2000. Early-stage toxicology and environmental chemistry, similar to the 1995 situation, remained a relatively minor component of the research process.

Product development costs in 2000 represented a total expenditure of $79 million, equivalent to 42.9% of the overall total. Within this category, field trails were the most significant costs with a value of $25 million, followed by developmental chemistry which accounted for a further $20 million and toxicology which was valued at $18 million The remaining expenditure in product development was environmental chemistry at $16 million.

Registration costs in 2000 were assessed at $11 million, equivalent to 6.0% of the total discovery and development expenditure.

Section: 1

Study Results 2005-08

Cost of New Product Discovery and Development – 2005-08

In total six companies were surveyed, responses from five have so far been received and are included in this report.

As with the 1995 data, some company responses were incomplete in that they did not contain information on all subcategories and as a result subcategory mean values were calculated on a pro rata basis.

The actual number of responses for each category and subcategory, and the mean values of the company responses are shown in the following table:

Discovery and Development Costs of a New Crop Protection Product (2005-2008)

Category	Subcategory	Cost ($ million)	Cost (€ million)	Number of Responses
Research	Chemistry	42	32	5
Research	Biology	32	24	5
Research	Toxicology/Environmental Chemistry	11	8	5
Research	**Research total**	**85**	**64**	**5**
Development	Chemistry	36	26	5
Development	Field Trials	54	40	5
Development	Toxicology	32	23	5
Development	Environmental Chemistry	24	17	5
Development	**Development total**	**146**	**107**	**5**
Registration		**25**	**18**	**5**
Total		**256**	**189**	**5**

Section: 1

Study Results 2005-08

The above results demonstrated that the overall costs for discovering and developing a new agrochemical product in 2005-08 period had risen to $256 million (€189 million).

Unlike the 1995 and 2000 results, product development has now exceeded research or discovery as the most significant category in new agrochemical R&D with an expenditure of $146 million, equivalent to 57% of the total. Within this category, field trials were the most significant cost with a value of $54 million, followed by developmental chemistry, which accounted for a further $36 million and toxicology, which was valued at $32 million The remaining expenditure in product development was environmental chemistry at $24 million.

Product research costs in 2005-08 represented a total expenditure of $85 million, equivalent to 33.2% of the overall total. Within this, new product chemistry was the most significant subcategory, representing an expenditure of $42 million followed by biological screening, which accounted for a further $32 million Early-stage toxicology and environmental chemistry, similar to the 2000 situation, remained a relatively minor component of the research process.

Registration costs in bringing a new product to market in the 2005-08 period were assessed at $25 million, equivalent to 9.8% of the total discovery and development expenditure.

Section: 1

Study Results 2010-14

Cost of New Product Discovery and Development – 2010-14

In total, five companies were surveyed and have provided responses that have been consolidated and presented in this report.

As with the previous data, some company responses were incomplete in that they did not contain information on all subcategories and as a result subcategory mean values were calculated on a pro rata basis.

The actual number of responses for each category and subcategory, and the mean values of the company responses are shown in the following table:

Discovery and Development Costs of a New Crop Protection Product (2010-2014)

Category	Subcategory	Cost ($ million)	Cost (€ million)	Number of Responses
Research	Chemistry	49	37	5
Research	Biology	51	38	5
Research	Toxicology/Environmental Chemistry	7	5	5
Research	**Research total**	**107**	**80**	**5**
Development	Chemistry	35	26	5
Development	Field Trials	47	36	5
Development	Toxicology	29	22	5
Development	Environmental Chemistry	35	26	5
Development	**Development total**	**146**	**110**	**5**
Registration		**33**	**25**	**5**
Total		**286**	**215**	**5**

Section: 1

Study Results 2010-14

The above results demonstrated that the overall costs for the discovery and development of a new agrochemical product in 2010-14 period had risen to $286 million (€215 million).

Similar to the results of the 2005-08 analysis, the development phase still accounted for the largest share of the R&D cost. However, between the 2005-08 and 2010-14, the cost of the development phase remained stable at $146 million. In comparison, the cost of the research phase increased by 25.9% to $107 million. The largest increase was however recorded by registration, up by 32.0% to $33 million, although these costs also include additional costs to achieve registration in the EU and USA.

In the development phase, the largest cost was field trials at $47 million, although these costs declined by 13.0% from 2005-08, however the largest increase was seen for environmental chemistry testing, up by 45.8% to $35 million.

In the research phase, the largest cost was biology (screening) at $51 million, up by 59.4%, however, unlike in the development phase, the cost of toxicology/environmental chemistry testing fell by 36.4% to $7 million.

Registration costs for bringing a new product to market in the 2010-14 period averaged $33 million, equivalent to 11.5% of the total discovery and development expenditure.

Section: 1

Study Results 2014-19

Cost of New Product Discovery and Development – 2014-19

In total five companies were surveyed, and all have provided responses that have been consolidated and presented in this report.

As with the previous data, some company responses were incomplete in that they did not contain information on all subcategories and as a result subcategory mean values were calculated on a pro rata basis.

The actual number of responses for each category and subcategory, and the mean values of the company responses are shown in the following table:

Discovery and Development Costs of a New Crop Protection Product (2014-2019)

Category	Subcategory	Cost ($ million)	Cost (€ million)	Number of Responses
Research	Chemistry	64	55	4
Research	Biology	52	45	4
Research	Toxicology/Environmental Chemistry	11	9	4
Research	**Research total**	**127**	**110**	**4**
Development	Chemistry	30	26	5
Development	Field Trials	58	50	5
Development	Toxicology	22	19	5
Development	Environmental Chemistry	22	19	5
Development	**Development total**	**133**	**115**	**5**
Registration		**42**	**36**	**5**
Total		**301**	**261**	**5**

Section: 1

Study Results 2014-19

The above results demonstrated that the overall costs for the discovery and development of a new agrochemical product in 2014-19 period had risen to $301 million (€261 million) from $286 m in the previous iteration.

In nominal ($) terms, costs associated with research have increased by 18.9% from $107 million (2010-2014) to approximately $127 million for the 2014-2019 period. Meanwhile, costs associated with product development have decreased by 8.5% from $146 million in the previous iteration to $133 million for the 2014-2019 period. Registration costs also increased, rising by 25.9% from $33 million (2010-2014) to $42 million (2014-2019).

In the research phase, the largest cost was chemistry at $64 million, up by 31.6%. The cost of toxicology/environmental chemistry testing increased by 58.4% to $11 million, whilst the cost of biological screening increased by 1.4% to $52 million.

In the development phase, the greatest cost was field trials at $58 million, representing a 23.9% increase over comparable figures from the previous iteration. Costs of all other developmental phases declined.

Registration costs for bringing a new product to market in the 2014-2019 period averaged $42 million, equivalent to 13.9% of the total discovery and development expenditure.

Costs associated with product development still account for the largest share of total R&D costs at approximately 44.2%. However, unlike in the previous iteration, product development costs are comparable to costs associated with the research phase, which accounted for approximately 42.0% of total R&D costs. Registration costs account for approximately 13.9% of the total spend.

Section: 1

Study Results Comparison

Comparison between 1995, 2000, 2005-08, 2010-14 and 2014-19 Costs

The following table summarises the 1995, 2000, 2005-08, 2010-14 and 2014-19 survey results.

New Crop Protection Product Discovery and Development Costs (2014-19 vs 2010-14, 2005-08, 2000 and 1995)

Category	Subcategory	Cost ($ million) 1995	Cost (€ million) 2000	Cost ($ million) 2005-08	Cost (€ million) 2010-14	Cost ($ million) 2014-19	Change % 2014-19 / 2010-14
Research	Chemistry	32	41	42	49	64	31.6
Research	Biology	30	44	32	51	52	1.4
Research	Toxicology/ Environmental Chemistry	10	9	11	7	11	58.4
Research	**Research total**	**72**	**94**	**85**	**107**	**127**	**18.9**
Development	Chemistry	18	20	36	35	30	-13.3
Development	Field Trials	18	25	54	47	58	23.9
Development	Toxicology	18	18	32	29	22	-23.4
Development	Environmental Chemistry	13	16	24	35	22	-35.4
Development	**Development total**	**67**	**79**	**146**	**146**	**133**	**-8.5**
Registration		**13**	**11**	**25**	**33**	**42**	**26.5**
Total		**152**	**184**	**256**	**285**	**301**	**5.7**

Section: 1

Study Results Comparison

The above results demonstrate that the overall costs of discovery and development for a new crop protection product for the EU and the USA markets have risen by 5.5% from 2010-14 to reach $301 million in 2014-19.

In 2005-08, biology costs were believed to have declined due to the adoption of advanced rapid throughput screening/genomics. However, biology costs in 2010-14 increased to over the level of 2000. In the latest edition, the cost associated with biological product screening has increased marginally over the 2010-14 figure, however, the composition of costs has significantly changed, with costs of efficacy testing (-14.3%) and small plot trials (-70.0%) declining, whilst the cost of field trials has increased by 131.5%.

Similarly, in 2005-08 combinatorial chemistry was thought to have slowed the increase in the cost of chemical synthesis. However, these techniques have lost some popularity and the chemistry / synthesis cost in the research phase increased significantly in the period to 2010-14. In the 2014-19 period, chemical synthesis costs increased by a further 30.5% to $61.3 million. Research costs of formulations technologies has also increased significantly, rising by 61.6% to $2.7 million.

It is a major commercial decision for a company to progress a product candidate from Research into Development and dedicate a further $175 million in costs (development and registration) to bring that product to market. The company needs to be confident with the efficacy, safety and commercial potential of a candidate product to make this decision, particularly passing the more and more stringent regulatory requirements, reflected by the increased expenditure across all sectors of the Research phase.

In the development phase, the cost of chemistry (phase up to production of commercial quantities and formulation development) declined between 2010-14 and 2014-19. This follows a marginal decrease in the cost of chemistry from 2005-08 to 2010-14. The costs of scaling up manufacturing have fallen 18.7% to $21.6 million, whilst the costs of developing formulation technologies have increased 3.7% to $8.7 million.

Toxicology costs in the development cycle rose rapidly from 2000 to 2005-08 but fell again in the 2010-14 period. In the latest period, toxicology costs have fallen a further 23.4% to $21.9 million, driven by a 27.4% decline in chronic mammalian toxicology costs and an 18.7% decline in environmental toxicology costs. It is worth noting that some of these costs have transferred to the research phase where mammalian acute toxicology costs (+114.4) and mammalian sub chronic toxicology costs (+78.3%) have increased.

Section: 1

Study Results Comparison

Field trial costs in the development phase overall increased by 23.9% between 2010-14 and 2014-19 to $58.4 million, following a decline in the previous edition. The latest survey also shows that large field trial costs have increased substantially from $9.9 million to $23.1 million, whilst registration field trial costs have declined by 5.1% to $35.3 million.

The survey results indicate that environmental costs have declined from the 2010-14 edition, falling by 35.4% to $22.5 million. Environmental residue costs have nearly halved, whilst the expenditure on metabolic studies declined by 6.9%.

Average registration costs associated with bringing a new AI to market have increased by 25.9% in the 2014-19 survey to $41.8 million. Within this, costs associated with statutory fees and internal registration activities have decreased significantly across both EU and US geographies. However, additional costs regarding specific studies that are only requested in the EU or US and have no use in any other country or registration region have increased by 91.6% in the EU to $17.4 million and by 94.6% to $14.4 million in the US, accounting for a combined 76.2% of registration costs.

Discussion

There are several considerations to keep in mind when comparing inter-company costs. Firstly, it is likely that the participating companies will have different rules regarding cost allocations within a development project, which has the potential to introduce significant inter-company variability.

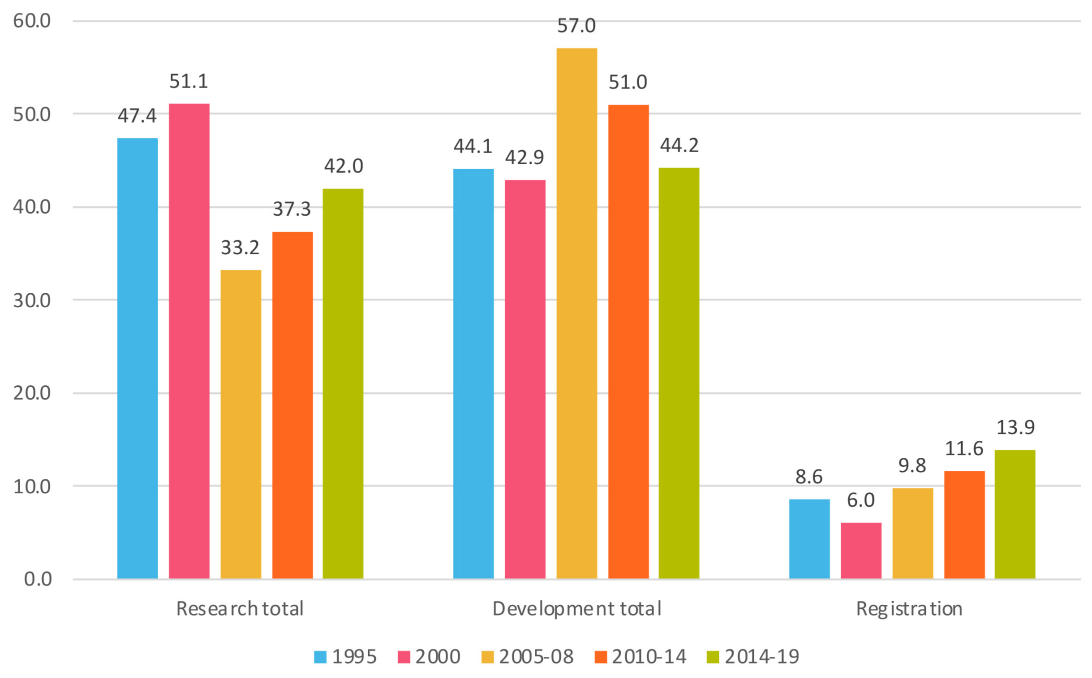
Other considerations include the impact of the surveys timing on company R&D expenditure. For example, participants noted that new product R&D does not happen at regular time intervals and instead noted that R&D projects for new active ingredients tend to occur in batches during periods of intensive R&D expenditure. Consequently, whether a company's strategy is oriented towards new product R&D during the surveys observation period will significantly impact expenditure and consequently will impact inter-company variability.

It is also worth highlighting that the scope in terms of geography and complexity will vary between product development projects within indications.

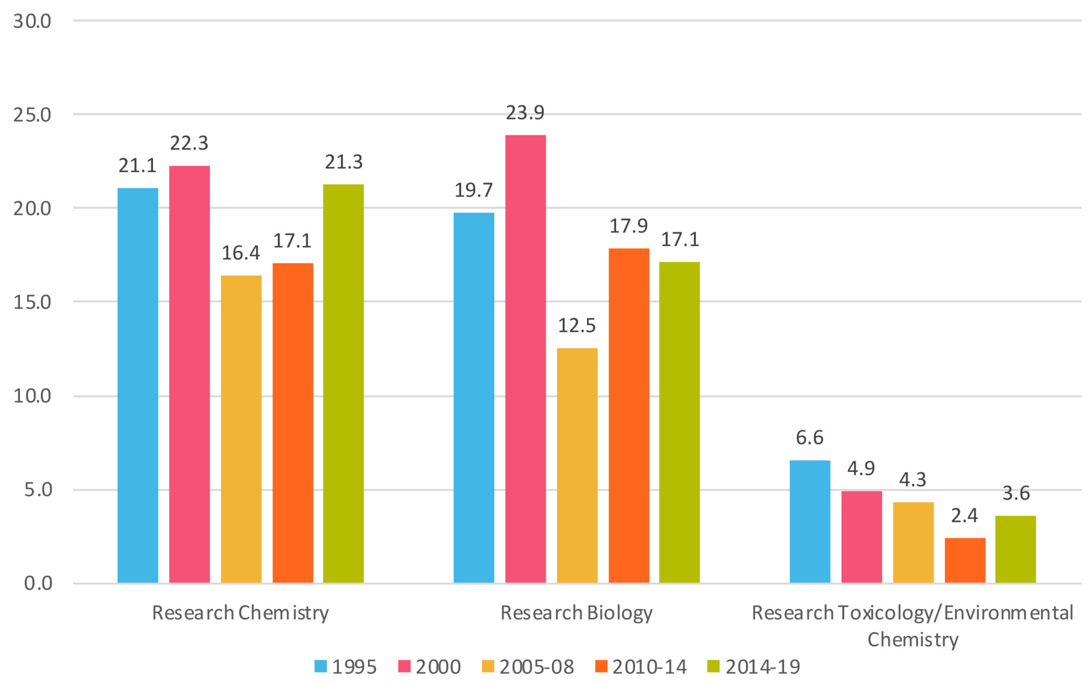
Detailed Comparison of Historical Results (2014-19 versus 2010-14 & 2005-08)						
Category	Sub-category	Sector	Cost ($ million)			Change %
			2005-08	2010-14	2014-19	2014-19 / 2010-14
Research	Chemistry	Synthesis	41.4	47.0	61.3	30.5
Research	Chemistry	Formulation	0.6	1.7	2.7	61.6
Research	**Chemistry Total**		**42.0**	**48.7**	**64.1**	**31.6**
Research	Biology	Efficacy Testing (Glasshouse)	23.5	41.3	35.4	-14.3
Research	Biology	Small plot trials	3.9	3.0	0.9	-70.0
Research	Biology	Field trials	4.7	6.6	15.3	131.5
Research	**Biology Total**		**32.1**	**50.9**	**51.6**	**1.4**
Research	Toxicology	Mammalian acute	2.4	2.3	4.9	114.4
Research	Toxicology	Mammalian sub chronic	4.6	1.4	2.5	78.3
Research	Toxicology	Environmental	1.9	1.3	0.9	-28.1
Research	**Toxicology Total**		**8.9**	**5.0**	**8.4**	**67.2**
Research	Environmental Chemistry	Residue analysis	0.4	0.8	0.7	-15.4
Research	Environmental Chemistry	Metabolism	2.0	1.1	1.9	72.1
Research	**Environmental Chemistry Total**		**2.4**	**1.9**	**2.6**	**35.3**
Research Total			**85.4**	**106.5**	**126.6**	**18.9**
Development	Chemistry	Scale up of Manufacture	19.7	26.6	21.6	-18.7
Development	Chemistry	Formulation	16.5	8.4	8.7	3.7
Development	**Chemistry Total**		**36.2**	**35.0**	**30.3**	**-13.3**
Development	Biology	Large Scale Field trials	43.4	9.9	23.1	133.1
Development	Biology	Registration Field trials	11.0	37.2	35.3	-5.1
Development	**Biology Total**		**54.4**	**47.1**	**58.4**	**23.9**
Development	Toxicology	Chronic Mammalian	21.9	15.4	11.2	-27.4
Development	Toxicology	Environmental	9.9	13.2	10.7	-18.7
Development	**Toxicology Total**		**31.8**	**28.6**	**21.9**	**-23.4**
Development	Environmental Chemistry	Metabolism	15.3	11.7	10.9	-6.9
Development	Environmental Chemistry	Residues	8.4	23.1	11.6	-49.8
Development	**Environmental Chemistry Total**		**23.7**	**34.8**	**22.5**	-35.4
Development Total			**146.1**	**145.5**	**133.1**	**-8.5**
Registration	EU	Registration fees	5.7	5.2	2.2	-58.5
Registration	EU	Internal Registration Costs	13.5	5.6	4.7	-15.6
Registration	EU	Additional studies*	2.3	9.1	17.4	91.6
Registration	**EU Total**		**21.5**	**19.9**	**24.3**	**22.2**
Registration	US	Registration fees	0.6	2.9	2.1	-26.9
Registration	US	Internal Registration Costs	1.3	3.0	1.0	-68.2
Registration	US	Additional studies*	1.5	7.4	14.4	94.6
Registration	**US Total**		**3.4**	**13.3**	**17.5**	**31.4**
Registration Total			**24.9**	**33.2**	**41.8**	**25.9**
Grand Total			**256.4**	**285.2**	**301.5**	**5.7**

Section: 1 Study Results Comparison

New Crop Protection Product Discovery and Development Costs (% of Overall Costs)

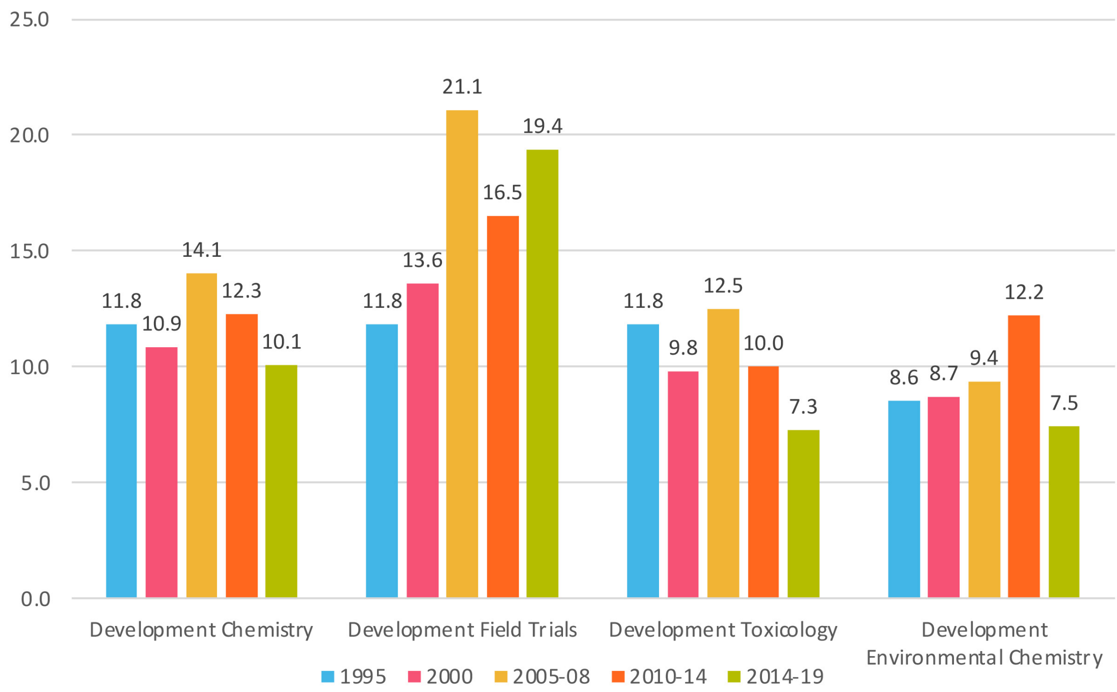


New Crop Protection Product Research Costs (% of Overall Costs)



Section: 1 Study Results Comparison

New Crop Protection Product Discovery and Development Costs (% of Overall Costs)



New Crop Protection Product Discovery and Development Costs (% of Overall Costs)

	1995	2000	2005-08	2010-14	2014-19
Research Chemistry	21.1	22.3	16.4	17.1	21.3
Research Biology	19.7	23.9	12.5	17.9	17.1
Research Toxicology/Environmental Chemistry	6.6	4.9	4.3	2.4	3.6
Research total	**47.4**	**51.1**	**33.2**	**37.3**	**42.0**
Development Chemistry	11.8	10.9	14.1	12.3	10.1
Development Field Trials	11.8	13.6	21.1	16.5	19.4
Development Toxicology	11.8	9.8	12.5	10.0	7.3
Development Environmental Chemistry	8.6	8.7	9.4	12.2	7.5
Development total	**44.1**	**42.9**	**57.0**	**51.0**	**44.2**
Registration	**8.6**	**6.0**	**9.8**	**11.6**	**13.9**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

New Crop Protection Product Discovery and Development Costs (% of Overall Costs)					
Category	**Subcategory**	**Sector**	**2005-08**	**2010-14**	**2014-19**
Research	Chemistry	Synthesis	16.2	16.5	20.3
Research	Chemistry	Formulation	0.2	0.6	0.9
Research	**Chemistry Total**		**16.4**	**17.1**	**21.3**
Research	Biology	Efficacy Testing (Glasshouse)	9.2	14.5	11.8
Research	Biology	Small plot trials	1.5	1.1	0.3
Research	Biology	Field trials	1.8	2.3	5.1
Research	**Biology Total**		**12.5**	**17.9**	**17.1**
Research	Toxicology	Mammalian acute	0.9	0.8	1.6
Research	Toxicology	Mammalian sub chronic	1.8	0.5	0.8
Research	Toxicology	Environmental	0.7	0.5	0.3
Research	**Toxicology Total**		**3.5**	**1.8**	**2.8**
Research	Environmental Chemistry	Residue analysis	0.2	0.3	0.2
Research	Environmental Chemistry	Metabolism	0.8	0.4	0.6
Research	**Environmental Chemistry Total**		**0.9**	**0.7**	**0.9**
Research Total			**33.3**	**37.3**	**42.0**
Development	Chemistry	Scale up of Manufacture	7.7	9.3	7.2
Development	Chemistry	Formulation	6.4	3.0	2.9
Development	**Chemistry Total**		**14.1**	**12.3**	**10.1**
Development	Biology	Large Scale Field trials	16.9	3.5	7.7
Development	Biology	Registration Field trials	4.3	13.0	11.7
Development	**Biology Total**		**21.2**	**16.5**	**19.4**
Development	Toxicology	Chronic Mammalian	8.5	5.4	3.7
Development	Toxicology	Environmental	3.9	4.6	3.6
Development	**Toxicology Total**		**12.4**	**10.0**	**7.3**
Development	Environmental Chemistry	Metabolism	6.0	4.1	3.6
Development	Environmental Chemistry	Residues	3.3	8.1	3.8
Development	**Environmental Chemistry Total**		**9.2**	**12.2**	**7.5**
Development Total			**57.0**	**51.0**	**44.2**
Registration	EU	Registration fees	2.2	1.8	0.7
Registration	EU	Internal Registration Costs	5.3	2.0	1.6
Registration	EU	Additional studies*	0.9	3.2	5.8
Registration	**EU Total**		**8.4**	**7.0**	**8.1**
Registration	US	Registration fees	0.2	1.0	0.7
Registration	US	Internal Registration Costs	0.5	1.1	0.3
Registration	US	Additional studies*	0.6	2.6	4.8
Registration	**US Total**		**1.3**	**4.7**	**5.8**
Registration Total			**9.7**	**11.6**	**13.9**
Grand Total			**100.0**	**100.0**	**100.0**

Section: 1

Additional Costs & Product Development Lead Time

Additional Costs

This part of the questionnaire focussed on the quantification of any additional R&D costs associated with the discovery and development of a new crop protection product that had not been identified in Part 1 of the study.

A number of companies identified additional expenses covering registration fees and costs outside the EU and the US, averaging $9.3 million and additional toxicology studies focussing on human health and safety, averaging $21.0 million.

Product Development Lead Time

The final section of the questionnaire asked each company to provide details of the time from the first synthesis of a new crop protection product until the first sales of the product. Four companies included these details, and the mean values of the responses are outlined in the following table:

Crop Protection Product Discovery and Development Lead Time

Period	1995	2000	2005-08	2010-14	2014-19
No. years between initial product synthesis and the first product sale	8.3	9.1	9.8	11.3	12.3

Based on the results of the survey, over the period from 2010-14 to 2014-19, the lead time between the first synthesis of a new crop protection product and its commercialisation has increased from an average of 11.3 years to 12.3 years. This has occurred despite the adoption of rapid throughput techniques and enhanced fast track registration procedures for selected products. It is possible that the rise is due to an increase in the complexity and volume of data required by regulatory bodies and the time taken to develop this data. Another potential contributory factor could be the pressure on regulatory bodies to ensure that registration dossiers are absolutely complete prior to authorisation rather than issuing provisional approvals.

Section: 1

Survey Variance

Survey Variance

As described in the methodology section, one of the primary purposes of the study was to assess the level of expenditure made by crop protection companies that is required to discover, develop and register a new crop protection product for the EU and USA markets in 2014-19.

The companies chosen to participate in the survey were those that are considered to be active in novel active ingredient research and development. This is exemplified by the fact that these companies accounted for 75% of research and development expenditure of the leading 30 global agrochemical companies in 2019. (Source: Agbioinvestor AgbioCrop).

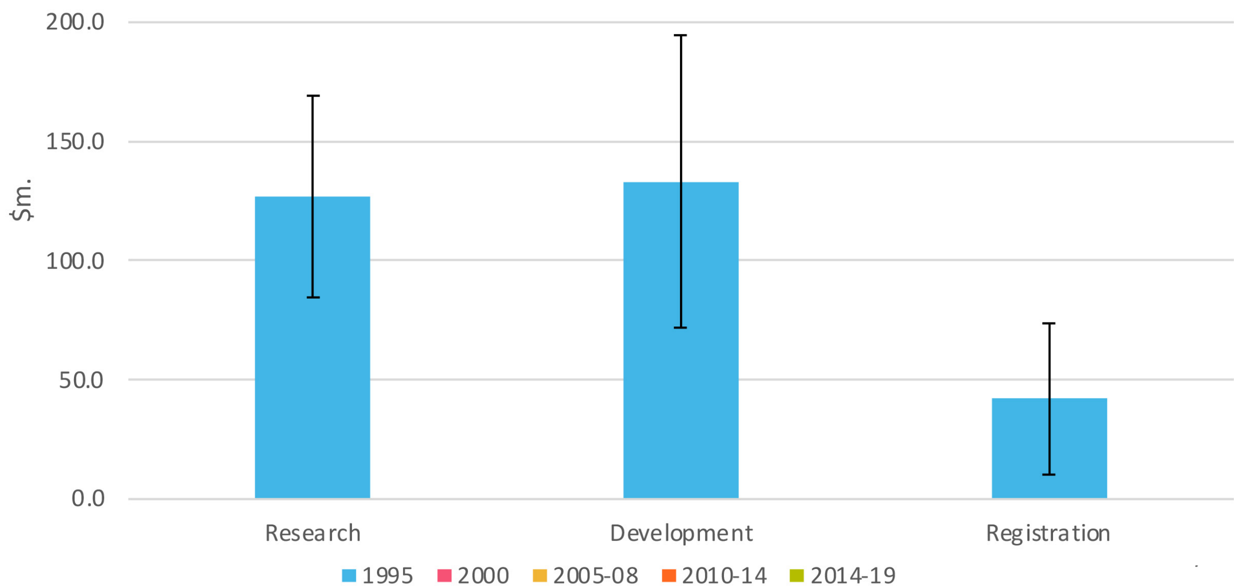
The survey results can therefore be considered to reflect those companies with a meaningful programme of new crop protection product discovery and development for the EU and the USA markets.

The following figure shows the mean value and variance (as measured by standard deviation) within the results of the survey on product discovery and development in 2014-19.

Survey Results - Mean and Standard Deviation

	Research	Development	Registration
Standard Deviation	42.4	61.3	31.9
Average ($ million)	126.6	133.1	41.8

Survey Results - Mean and Standard Deviation



Section 2: Breakdown of Expenditure Devoted to the R&D Process 2019

02

Section: 2

Introduction & Study Definitions

Introduction

In 2002 Phillips McDougall undertook a study on behalf of the European Crop Protection Association (ECPA, now CropLife Europe) and CropLife America that was designed to determine the level of expenditure involved in the discovery, development and registration of a new conventional chemical crop protection AI. As reported in Section 1 of this report, this study was repeated to provide information on the costs involved in bringing a new agrochemical active ingredient from the initial discovery process to the marketplace, however, the study does not provide information on the overall level of R&D expenditure or expectations for the future. A further study was undertaken on behalf of CropLife International regarding company R&D expenditure in 2004, this study was repeated in 2009, but for 2007 and expectations for 2012, and again in 2016, covering 2014 expenditure with expectations for 2019. This latest survey covers R&D expenditure in 2019, however, does not contain information regarding expectations for the future.
This survey undertaken and reported in this second section is designed to provide a greater understanding of the annual overall expenditure of the agrochemical industry on research and development.

Study Scope

As outlined above, this current study was designed to measure the overall level of expenditure devoted by the agrochemical industry to the research and development process..

- The proportion of the R&D budget that is targeted at new product discovery, development and managing the existing business, including product stewardship and monitoring.

Section: 2

Introduction & Study Definitions

Methodology

The results of this study are based on the responses to a questionnaire, which was sent to the following group of companies that were considered to be representative of the industry. The questionnaire that was sent to the companies is outlined in Appendix 3 of this report.
The companies that responded and that are included in the survey were:

- BASF Agricultural Solutions
- Bayer Crop Science
- Corteva Agriscience
- FMC

The responses of each company were added to a database, with each company allocated a code number. For companies reporting in non-US dollar terms, the values were converted to US dollar using average year exchange rates:

Average Exchange Rate to the US Dollar (2019):
Dollar = 0.865 €

The results of each company, in US dollar terms, were subsequently aggregated so that a collective total was produced to represent the overall agrochemical industry.

Section: 2

Introduction & Study Definitions

Study Definitions

The overall scope of the R&D process within the agrochemical industry encompasses the discovery of new agrochemical products and the research, developmental and regulatory processes associated with managing and maintaining the commercial and regulatory status of each company's products following their introduction.

Typically, the R&D process for new products can be split between activities relating to the screening and discovery of a new AI, and development. Both these stages involve a number of related scientific and regulatory disciplines that are designed to determine the relative efficacy of the product whilst ensuring that the new active ingredient satisfies the various tests established by regulatory bodies to demonstrate that the product is safe from both a human and environmental viewpoint.

In addition to the various studies associated with new product discovery, the agrochemical industry undertakes significant research and development to maintain and develop the existing product portfolio. Some of these studies will be undertaken to extend the application and use of the product following launch to other crop and pest scenarios or to other country markets. Increasingly a number of studies are also being undertaken to satisfy the re-registration requirements of regulatory bodies such as the EU and the US EPA.

The definition of R&D Expenditure and the main R&D phases that were included as categories in the questionnaire were:

R&D Expenditure (scope): The total expenditure on all agrochemical research and development activities for crop protection and non-agricultural uses. This covers R&D related to conventional crop protection in agriculture, pest control, industrial and consumer applications, public health and lawn and garden use. It also includes salaries and all other staff-related costs, as well as costs related to R&D administration, rent, supplies, equipment, materials, etc. Activities carried out (for the purpose of agrochemical development) within the corporation but outside the crop protection organization (for those companies having R&D centres/ capacities outside of crop protection divisions) are also included. Corporate research programs, expenditure on joint ventures, alliances, and research agreements with third parties are included. Depreciation costs related to R&D assets are also included. Capital expenditure on R&D is excluded.

Section: 2

Introduction & Study Definitions

Research of New Active Ingredients: All of the R&D activities associated with the discovery of new agrochemical active ingredients up to the start of new product development.

Development of new active ingredients: Starts at the point when a company commits a new active ingredient to full development, generally marked by the decision to commence long-term toxicity tests. It ends with the registration and launch of a product in a major crop market (generally an OECD country).

Post launch development: All product development activities following the launch of a new active ingredient into a major market.

- **Re-registration/registration maintenance:** refers to any activities or studies that must be undertaken in response to the requirements of registration authorities in order to maintain a product's registration.
- **Other**: includes activities required to satisfy regulatory requirements for registration in non-OECD countries and line extensions of existing products.

Development of Off-Patent products new to your company: The above sections predominately relate to the research and development of new active ingredients, however, a significant level of investment is made by generic companies in the development of off-patent products for introduction.

Product Monitoring and Stewardship: This relates to the costs associated with undertaking the requirements of the regulatory authorities post-introduction.

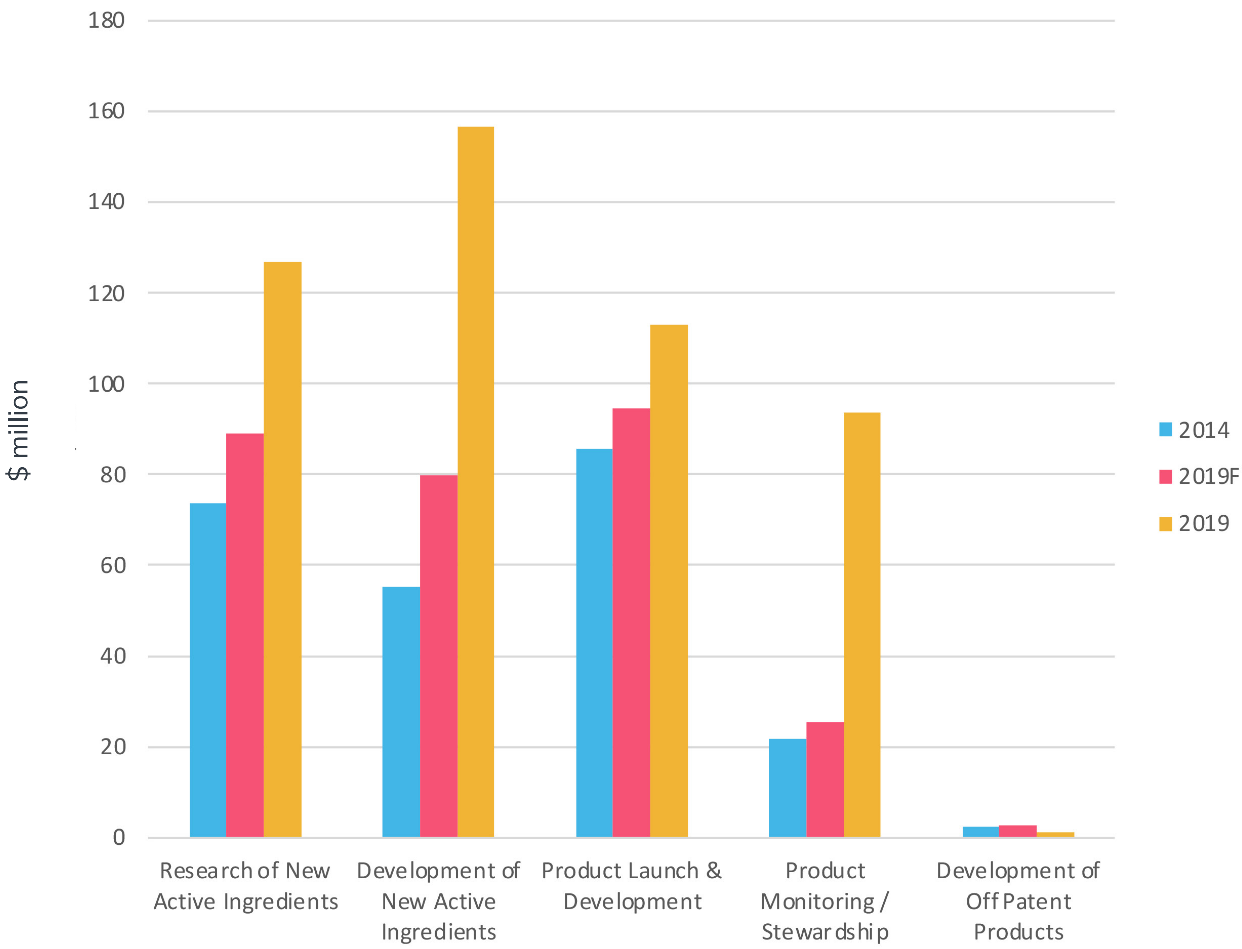
Section: 2

Study Results

Study Results: Breakdown of Expenditure Devoted to the R&D Process 2019

Responses to the survey were received from four companies. The total agrochemical R&D budgets in 2019 for the participating companies was $1,979 million, a value equivalent to 6.5% of the agrochemical sales of these companies.

Comparison of Average R&D Expenditure Breakdown of the Participating Companies

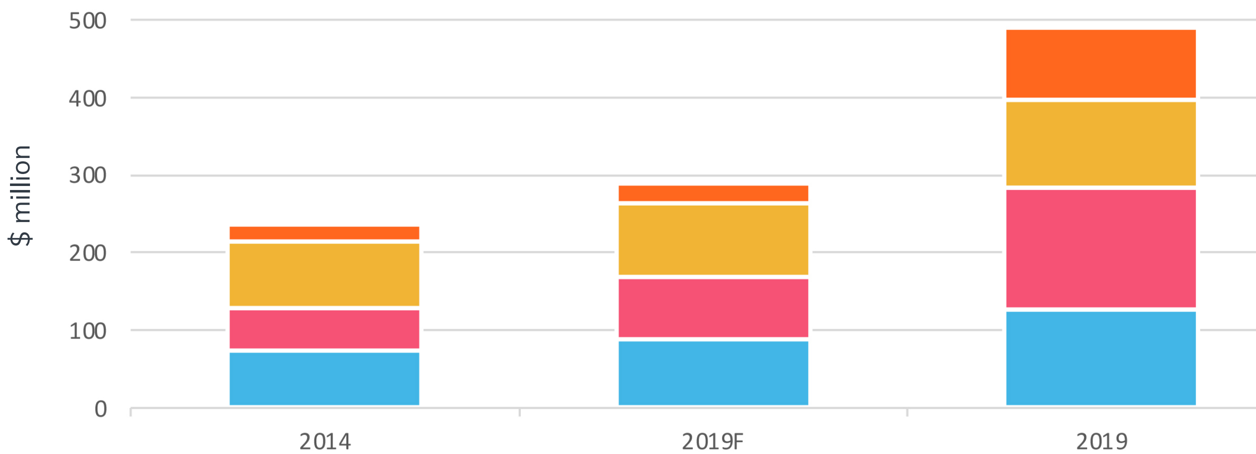


As can be seen in the graph above, the actual average R&D expenditure in 2019F far exceeded expectations for R&D expenditure in 2019 as surveyed in 2016 across all research and development functions, except for the development of off patent products. It is worth noting that the audience of surveyed companies has changed. This will influence the nature of average research and development expenditure.

Section: 2
Study Results

The average expenditure on activities relating to the research of new active ingredients has increased by 71.9% from $73.8 million in 2014 to $126.8 million in 2019, whilst costs associated with the development of new active ingredients have increased by 183.6% from $55.2 million to $156.6 million. The average costs associated with product launch and development have increased by 32.0% from $85.6 million to $113.0 million in 2019. Increases in costs associated with post-launch product monitoring and stewardship, which includes re-registration and registration maintenance costs, represent the most significant increases in costs compared with the previous survey, rising by 333.2% to $93.7 million.

Agrochemical Industry R&D Expenditure by Sector



Agrochemical Industry R&D Expenditure by Function of the Participating Companies

Function	2014		2019F		2019	
	$ million	% Share	$ million	% Share	$ million	% Share
Research of New Active Ingredients	74	30.9%	89	30.5%	127	25.8%
Development of New Active Ingredients	55	23.1%	80	27.4%	157	31.9%
Product Launch & Development	86	35.9%	95	32.5%	113	23.0%
Product Monitoring / Stewardship	22	9.1%	25	8.7%	94	19.1%
Development of Off Patent Products	2	1.0%	3	0.9%	1	0.3%
Total ($ million)	**239**		**292**		**491**	

Section: 2

Introduction & Study Definitions

Comparison with the last iteration of this study is of academic interest as the list of responding companies is different between the two studies. However, it does give an indication of changes in intentions.

As a proportion of the total research and development expenditure, the development of new active ingredients has increased from 23.1% in 2014 to 31.9% in 2019, whilst the research of new active ingredients has declined from 30.9% to 25.8%. Product launch and development expenditure has decreased as a proportion of the overall R&D expenditure, from 35.9% in 2014 to 23.0% in 2019, whilst product monitoring and stewardship increased from 9.1% to 19.1%, and the development of off patent products decreased from 1.0% to 0.3%.

In the previous survey, the expectation was that the research and discovery of new active ingredients in 2019 would constitute a similar proportion of the overall R&D budget as in 2014, declining marginally. However, the findings from the most recent survey indicate that the realised proportion of overall R&D budgets that is attributed to new active ingredient research has fallen to 25.8%.

A similar phenomenon is apparent regarding product launch and development costs, where the previous survey indicated that the expected proportion of the R&D budget that would be attributed to these activities would fall slightly from 35.9% to 32.5%, however, was expected to remain the largest proportionate cost of R&D activities.

The most recent responses indicate that the largest proportionate cost of R&D activities is now related to the development of new active ingredients, which accounts for 31.9% of the R&D budgets of the participants, far outstripping the expectations of the participants in the previous survey. Similarly, increases in the proportionate costs associated with product monitoring and stewardship have far outstripped expectations from the previous survey, where ongoing product monitoring and stewardship costs accounted for approximately a quarter of product development and launch costs.

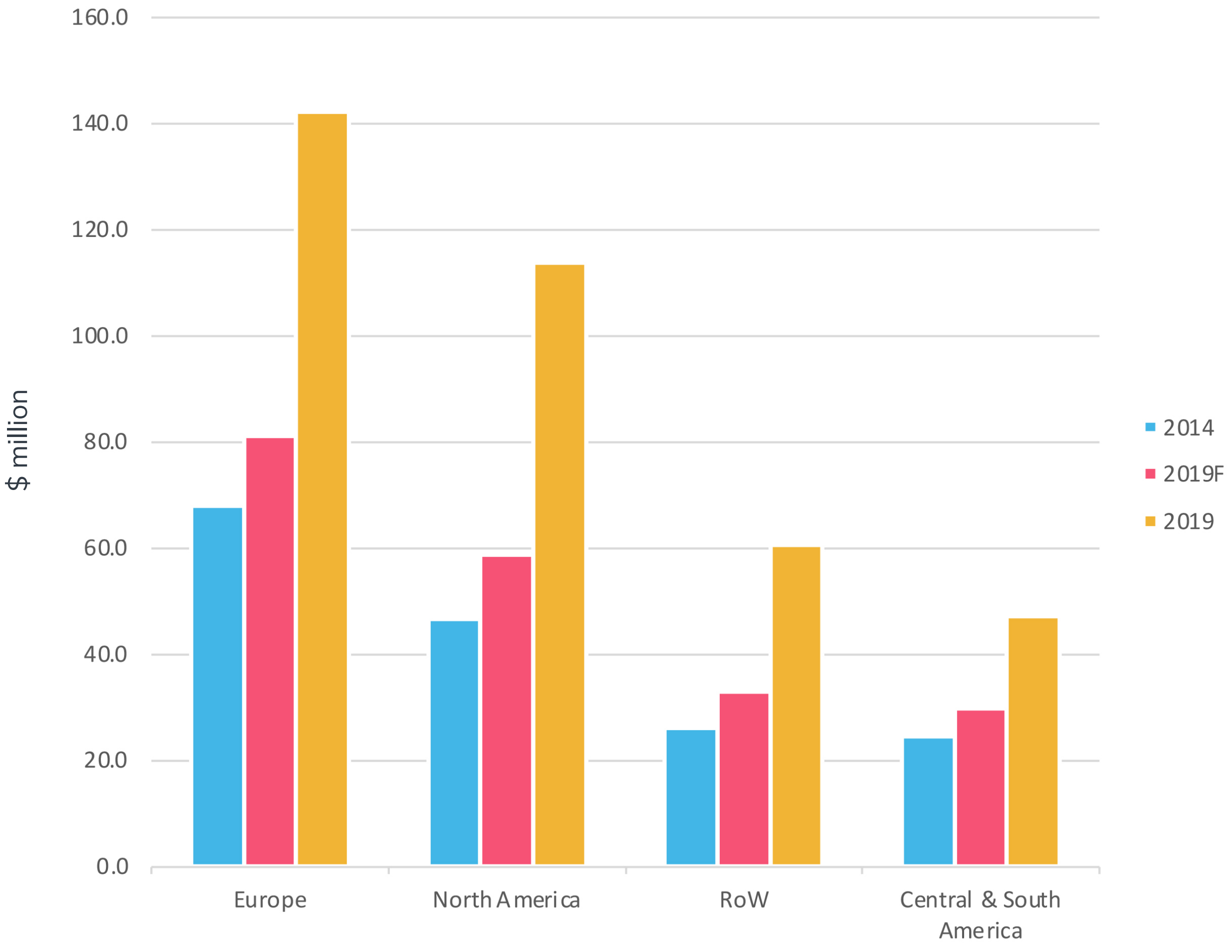
The most recent survey indicates that proportionate product monitoring and stewardship costs have more than doubled from 9.1% to 19.1% and are now comparable with costs attributed to initial product launch and development. This change in R&D budgeting represents the most significant divergence from the expectations of the previous survey, in which participants expected proportionate product monitoring and stewardship costs to decline marginally.

Section: 2

Introduction & Study Definitions

Respondents were also asked to provide a breakdown of development and stewardship costs by region (all of the R&D criteria except research of new active ingredients, which is more centrally focussed). The analysis was to focus on where products in development were targeted for introduction. The average total R&D expenditure that is targeted to specific geographies increased by 120.4% from $164.9 million in 2014 to $363.4 million in 2019.

Comparison of Average R&D Expenditure Breakdown of the Participating Companies by Region



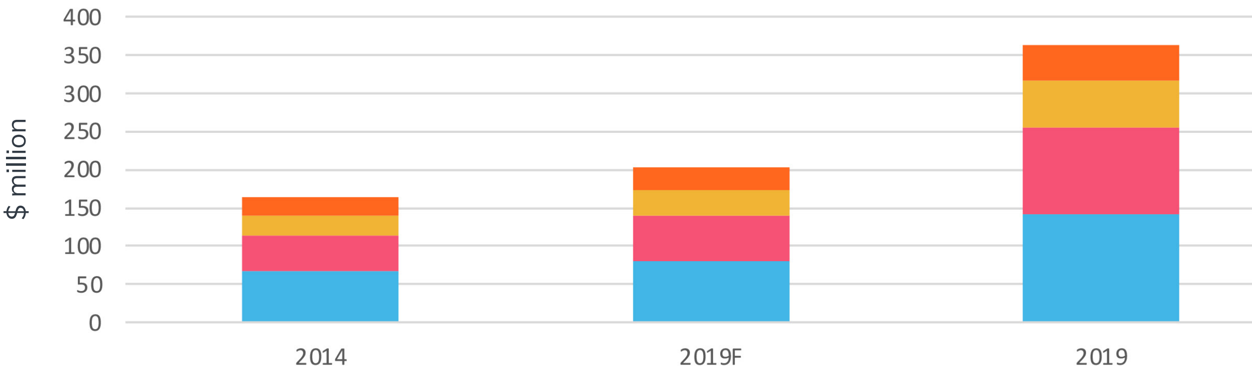
The graph above illustrates that the actual average R&D expenditure in 2019 far exceeded expectations for R&D expenditure in 2019 as surveyed in 2016 across all geographic markets. As previously mentioned, the audience of surveyed companies has changed, and this will influence the nature of average research and development expenditure. It is also worth highlighting that research and development costs associated with the research of new active ingredients are not included in this section as these costs are not targeted at a specific geography.

Section: 2

Introduction & Study Definitions

At the regional level, the average R&D expenditure across all geographies doubled, except for Central and South America, where R&D expenditure increased by 92.1% over 2014 to $47.1 million. In Europe, average R&D expenditure increased by 109.5% to $142.0 million, whilst in North America, comparative costs increased by 143.7% to $113.6 million, and in the Rest of the World costs increased by 133.6% to $60.7 million.

Agrochemical Industry R&D Expenditure by Region of the Participating Companies



Agrochemical Industry R&D Expenditure by Region of the Participating Companies

Region	2014		2019F		2019	
	$ million	% Share	$ million	% Share	$ million	% Share
Europe	68	41.1%	81	40.1%	142	39.1%
North America	47	28.3%	59	29.0%	114	31.3%
RoW	26	15.7%	33	16.3%	61	16.7%
Central & South America	25	14.9%	30	14.6%	47	13.0%
Total ($ million)	**165**		**203**		**363**	

The proportionate costs of product research and development in each of the tracked geographies has not changed significantly since the last survey.

As a proportion of overall geographically focussed R&D expenditure, expenditure targeted at the European market represented 39.1%, down from 41.1% in 2014, whilst costs focussed on the North American market increased to 31.3% of the overall in 2019, up from 28.3%. The direction of both these changes are in line with the expectations of the participants of the previous survey, however the actual magnitude of both changes is more extreme in reality.

Section: 2

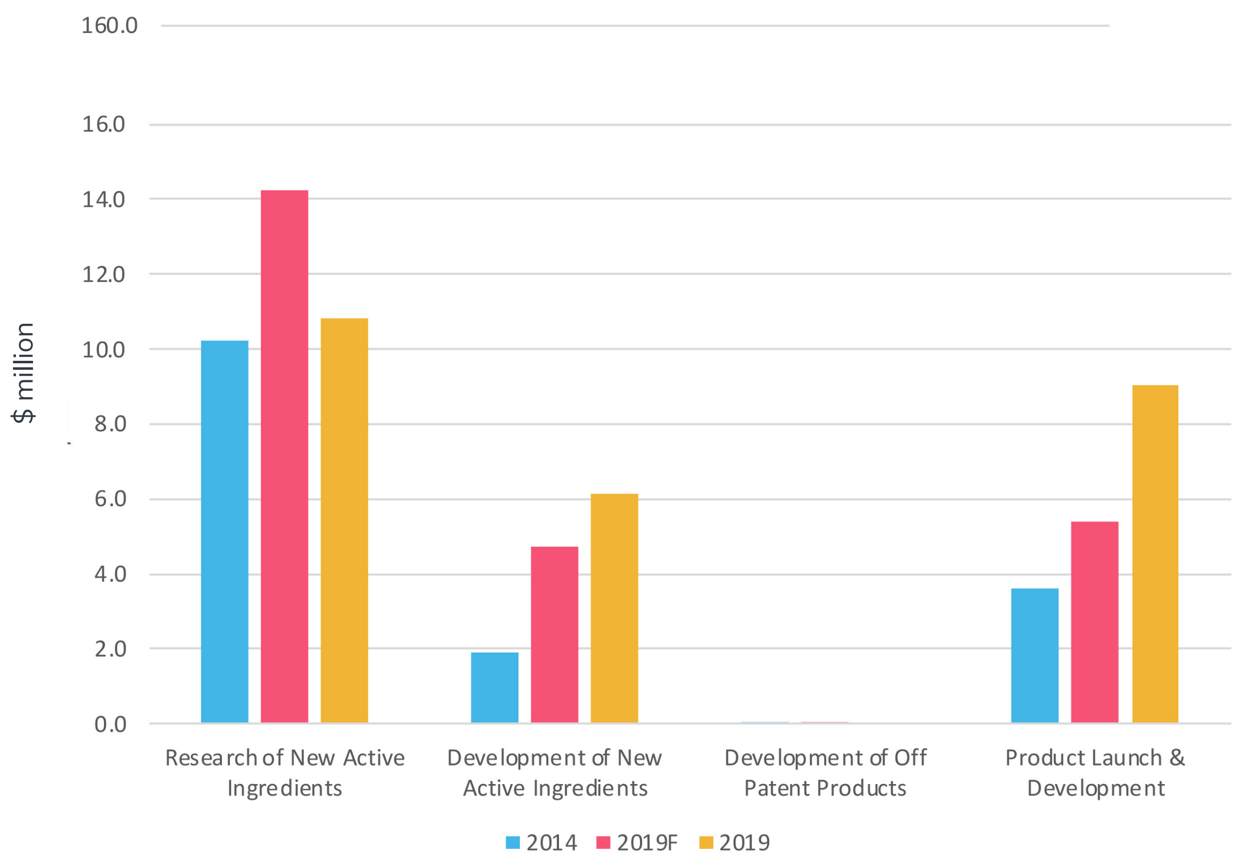
Introduction & Study Definitions

Meanwhile, the comparative figure for the Rest of the World region increased from 15.7% in 2014 to 16.7% in 2019, whilst in Central and South America, the figure fell from 14.9% to 13.0% in 2019. Again, the direction of these changes reflects the expectations of the participating companies in the last survey, however, the realised magnitude of the changes is more extreme.

Respondents were asked to provide a breakdown of R&D costs between chemical and biocontrol products (all the R&D criteria above except product monitoring and stewardship). In 2019, the average budget was $396.4 million, representing an increase of 82.7% over 2014.

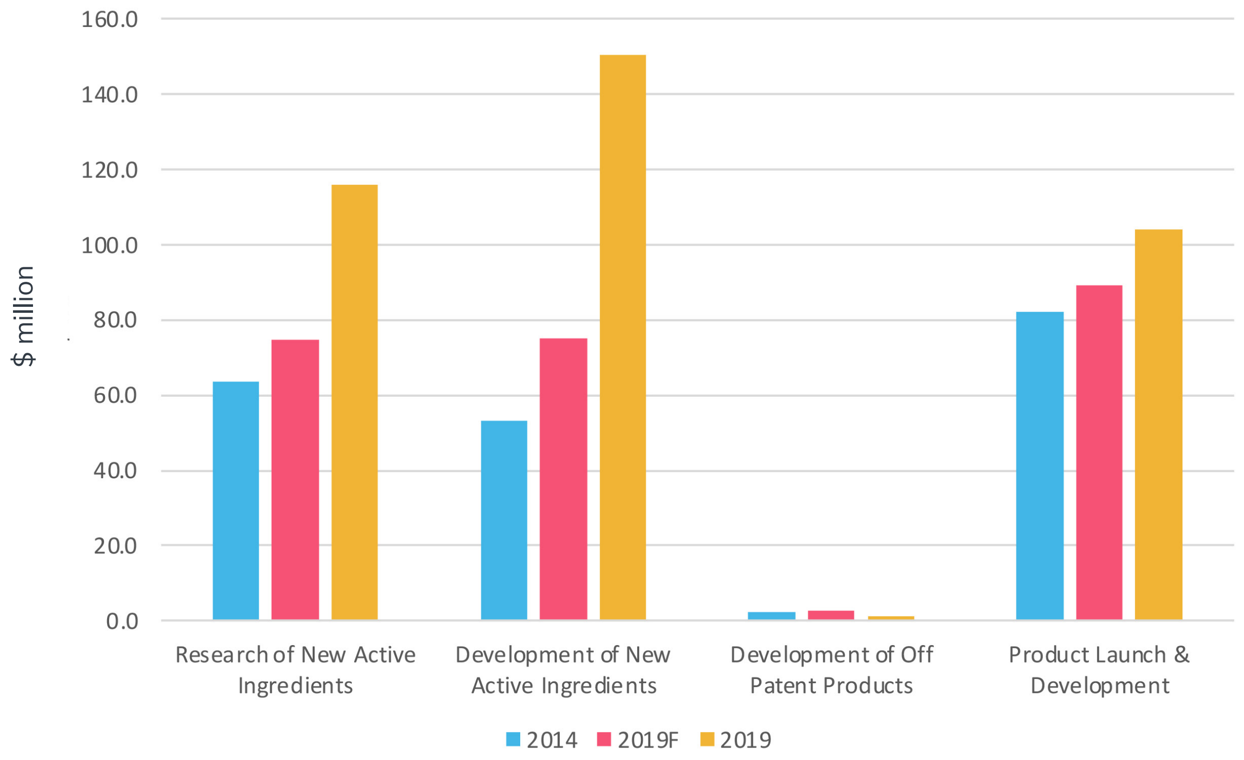
The following tables represent the average of the responses received from the participating companies. The data has been presented graphically and discussed below.

Agrochemical Industry Biological CP R&D Expenditure by Function

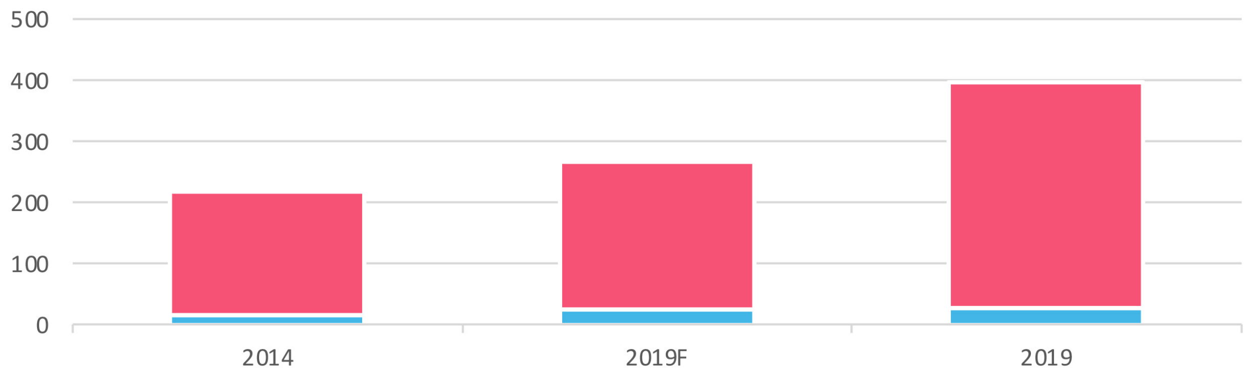


Section: 2 Introduction & Study Definitions

Agrochemical Industry Chemical R&D Expenditure by Function



Section: 2 Introduction & Study Definitions



Agrochemical Industry R&D Expenditure by Region of the Participating Companies						
Sector	2014		2019F		2019	
	$ million	% Share	$ million	% Share	$ million	% Share
Biologicals	16	7.3%	24	9.2%	26	6.6%
Chemical	201	92.7%	242	90.8%	370	93.4%
Total ($ million)	**217**		**266**		**396**	

The latest survey results indicate that R&D expenditure on both the chemical and biological crop protection product sectors increased in value terms. Research and development expenditure for biological crop protection products increased by 64.7% in absolute terms to $26.0 million, while the equivalent expenditure on chemical products increased by 84.1% to $370.4 million.

In 2014, chemical products accounted for 92.7% of the R&D budget, with expectations that this figure would fall to 90.8% in 2019 on account of the growing significance of the biological crop protection market. However, the latest survey indicates that the proportionate costs of chemical product R&D have actually increased to 93.4%.

It should, however, be remembered that the respondents in this study were predominantly the leading crop protection companies, some of which have acquired positions in the Biocontrol sector. There are also many other companies with interests in the Biocontrol industry that were not part of this survey.

February 2024

Section 3: CODEX MRL Costs 2014-19

03

Section: 3

Introduction & Study Scope

Introduction

In 2023 AgbioInvestor undertook a study on behalf of the CropLife International that was designed to determine the level of expenditure associated with obtaining and maintaining a CODEX Maximum Residue Limit (MRL) for a new active ingredient.

Study Scope

This study presents the results of a survey of the leading crop protection companies in order to determine:

- The overall level of expenditure associated with obtaining a CODEX MRL for a new active ingredient during the period between 2014 and 2019.
- The costs associated with obtaining additional uses of a CODEX MRL beyond the scope of the initial application during the period from 2014 to 2019.
- The costs associated with maintaining a CODEX MRL through periodic review between 2014 and 2019.

A MRL is the maximum concentration of a pesticide residue (expressed as mg/kg), to be legally permitted in or in food commodities and animal feeds when pesticides or crop protection products are applied correctly in accordance with Good Agricultural Practice (GAP). The amounts or residues in and on food/feed must be safe for consumers and as low as reasonably achievable.

CODEX MRLs are internationally agreed food standards covering pesticide residues in or on food and feed, with pesticide residue limits evaluated by the Joint Meeting on Pesticides Residues (JMPR) of the Food and Agriculture Organisation (FAO) of the United Nations and the World Health Organisation (WHO). Each year the JMPR recommends MRLs to the CODEX Committee on Pesticide Residues (CCPR) for consideration to be adopted by the Codex Alimentarius Commission (CAC) as CODEX MRLs.

Section: 3

Methodology

Methodology

The results of this study are based on the responses to a questionnaire, which was sent to the following group of companies that were considered to be representative of the industry. The questionnaire that was sent to the companies is outlined in Appendix 3 of this report.

The companies that responded and that are included in the survey were:

- BASF Agricultural Solutions
- Bayer Crop Science
- Corteva Agriscience
- Syngenta Crop Protection AG

The responses of each company were added to a database, with each company allocated a code number. For companies reporting in non-US dollar terms, the values were converted to US dollars using average year exchange rates:

Average Exchange Rate to the US Dollar (2014-2019):
Dollar = 0.865 €

Section: 3

Study Results

Study Results: CODEX MRL Costs 2014-19

Responses to the survey were received from four companies. The average total cost of obtaining a CODEX MRL was $164,000, with the average cost of submissions per additional use valued at $66,000 and the average cost of periodic reviews at $153,000. Inter-company variability was largest for costs associated with periodic review of CODEX MRLs, followed by costs of submission for additional uses and costs of obtaining a CODEX MRL for a new active ingredient.

CODEX MRL Costs		
Currency	**$ million**	**€ million**
New Active Ingredient	0.164	0.142
Per Additional Use	0.066	0.057
Periodic Review	0.153	0.132

Section 4: Re-registration Costs

04

Section: 4

Introduction & Study Scope

Introduction

In 2023 AgbioInvestor undertook a study on behalf of CropLife International that was designed to determine the level of expenditure associated with the re-registration process of an active ingredient that was re-registered within the 2014 to 2019 time frame.

Study Scope

This study presents the results of a survey of the leading crop protection companies in order to determine:

- The overall level of expenditure associated with re-registering an active ingredient within the 2014 to 2019 time frame.
- The costs associated with re-registering an active ingredient in each of the major crop protection markets (EU, US and Other jurisdictions).

Methodology

The results of this study are based on the responses to a questionnaire, which was sent to the following group of companies that were considered to be representative of the industry. The questionnaire that was sent to the companies is outlined in Appendix 4 of this report.

The companies that responded and that are included in the survey were:

- BASF Agricultural Solutions
- Bayer Crop Science
- Corteva Agriscience

The responses of each company were added to a database, with each company allocated a code number. For companies reporting in non-US dollar terms, the values were converted to US dollars using average year exchange rates:

Average Exchange Rate to the US Dollar (2014-2019):
Dollar = 0.865 €

The results of each company, in US dollar terms, were subsequently aggregated so that a collective total was produced to represent the overall agrochemical industry.

Section: 4

Study Results

Study Results: Re-registration Costs

The survey responses indicate that costs associated with the re-registration of an active ingredient vary depending on geography and product type.

Regarding geography, re-registration costs were highest in the EU at $17.4 million, almost 7 times higher than re-registration costs in the US ($2.5 million) and more than 9 times higher than re-registration costs in other jurisdictions. The higher costs associated with re-registration in the EU is likely a result of the more stringent regulatory landscape that exists in this jurisdiction. For example, some participants indicated that it only tracked re-registration costs in the EU as data generated through the European application process is sufficient to support applications in other jurisdictions.

The survey results indicated that there was no significant relation between product type and costs associated with re-registration.

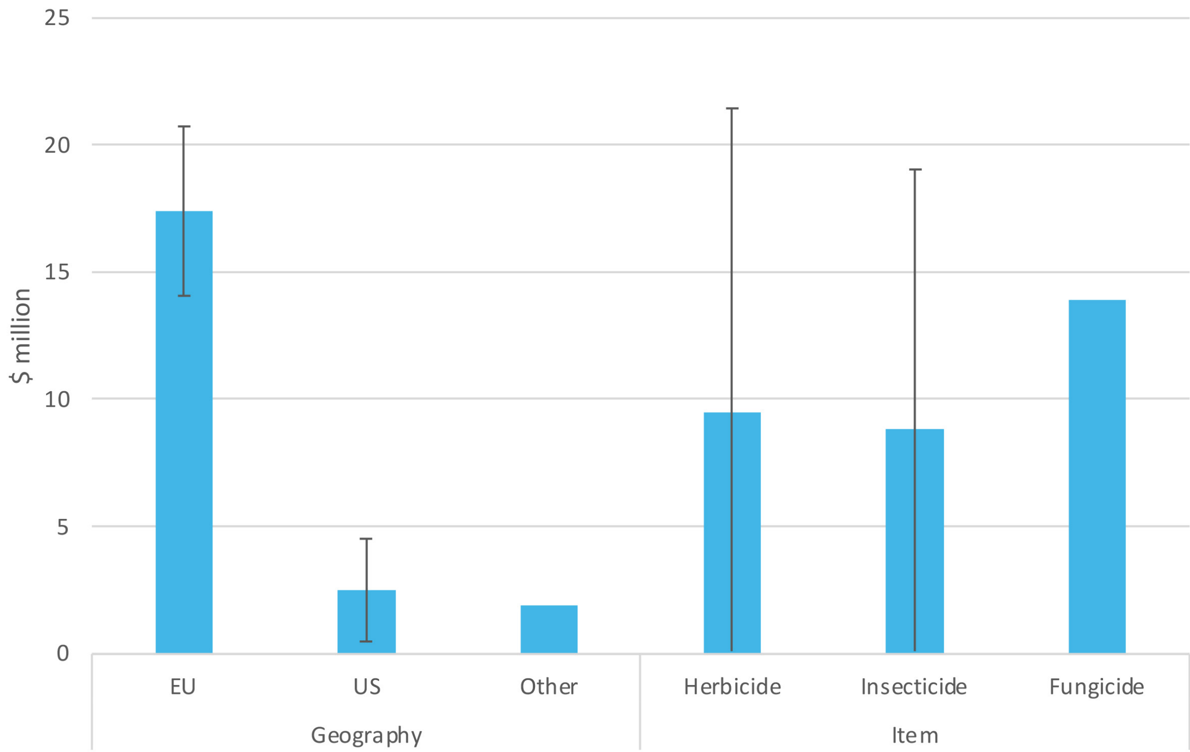
Costs Associated with Re-registering an AI Between 2014 and 2019

	Category	$ million	€ million	No. Responses
Geography	EU	17.4	15.1	3
	US	2.5	2.1	2
	Other	1.9	1.6	1
Item	Herbicide	9.5	8.2	2
	Insecticide	8.8	7.6	3
	Fungicide	13.9	12.0	1

Section: 4

Study Results

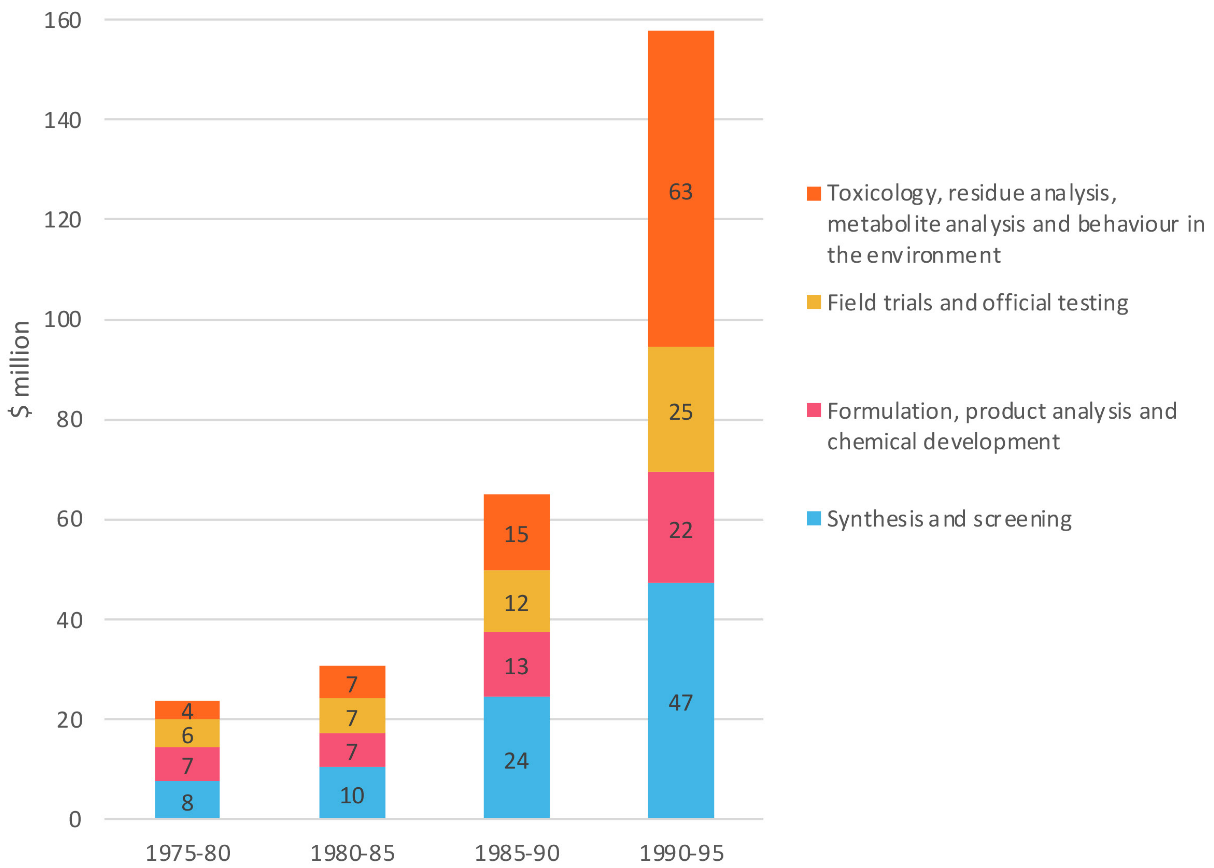
Costs Associated with Re-registering an Active Ingredient Between 2014 and 2019



Appendices

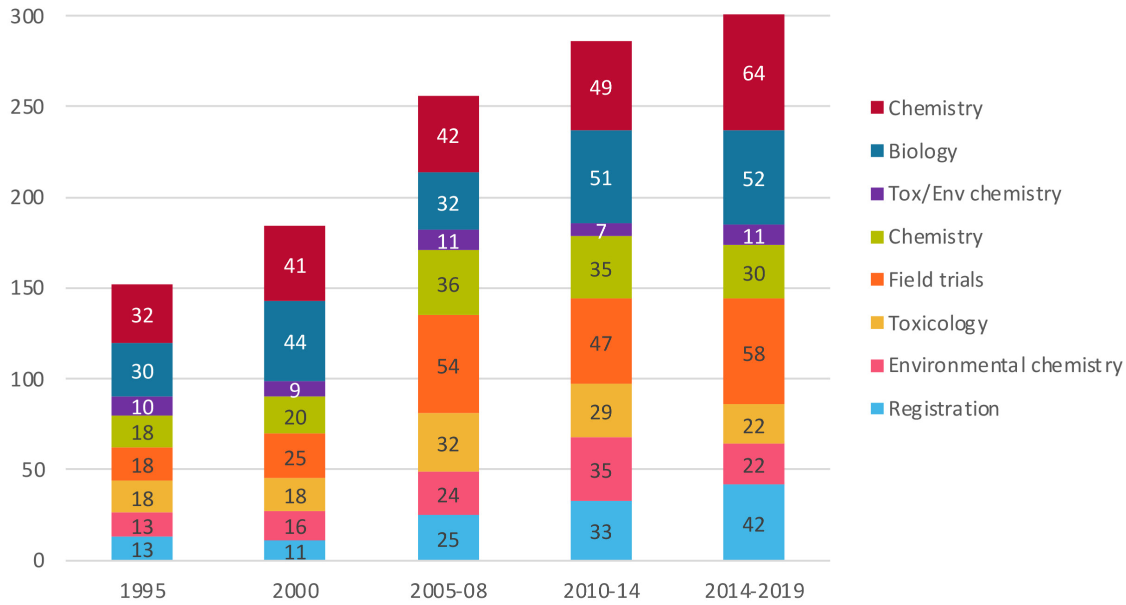
Appendix 1: Development Costs for a Crop Protection New Active Ingredient

Appendix 1: Development Costs for a Crop Protection Product

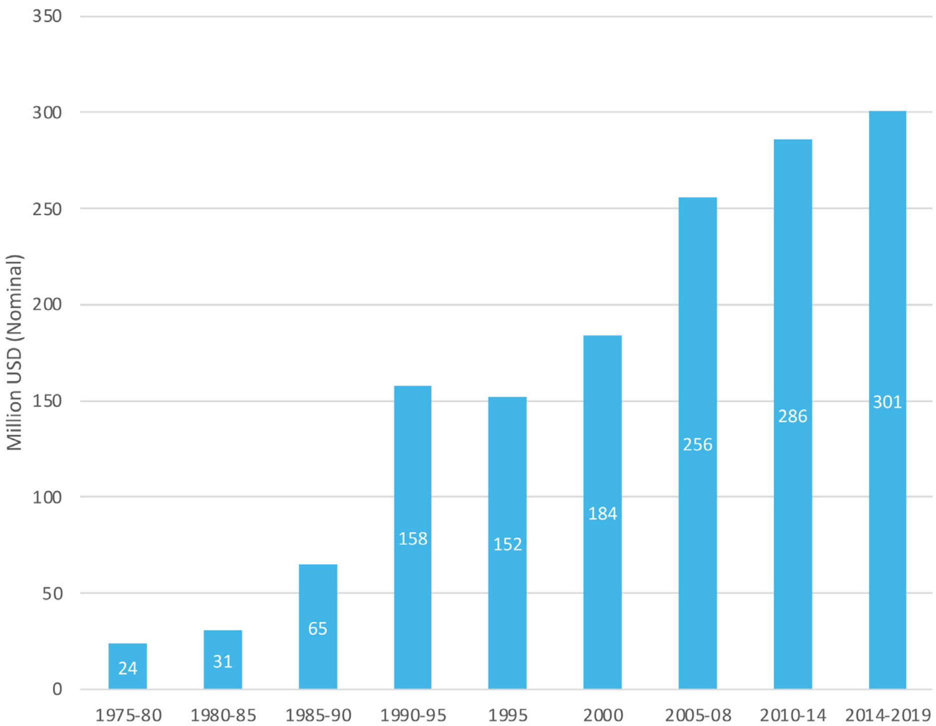


Appendix 2: Discovery and Development Costs of a New Crop Protection Active Ingredient

Appendix 2: Discovery and Development Costs of a New Crop Protection Product



Historical Comparison of Total Discovery and Development Costs of a New Crop Protection AI



Dues to changes in methodology and classifications of expenditure, results for 1995 and 2000 are looked at in singularity rather than over a defined 3-to-5-year period. The graph shows amalgamated survey results to demonstrate the change in overall expenditure over time.

Appendix 3: Study Questionnaire

Appendix 3: Study Questionnaire

Guidelines for Completing the R&D Questionnaire 1

Guidelines for Completing the Questionnaire

Please complete all parts of the questionnaire with the relevant data. Also please indicate the reporting currency.

Part 1: Breakdown of R&D Expenditure for Bringing a Single New Active Ingredient to a Major Market in the 2014–- 2019 Time frame.

It is recognised that the various cost allocation sectors outlined in the attached questionnaire are somewhat idealised and will depend to on the individual approach of each company to product research and development. However please complete each section according to what you believe best fits your company development programme. If you are able to identify a particular R&D cost that is not shown on the table we would be grateful if you could indicate this in the final section.

The object of the overall exercise is however to identify the average costs for the industry that are incurred in:

- Firstly, discovering a new crop protection active ingredient
- Secondly, in the whole process involved in product development through to product registration.

In addition, the study will look at identifying any costs that arise because of additional data or study requirements necessary for registration in the EU versus the USA and vice-versa. For this reason, it would be helpful if the development costs reflect those associated with a crop protection product that has applications in major food crops in the EU and the USA.

In completing the questionnaire, please bear in mind that the cost of the various studies associated with the research phase are those that are necessary to discover and register **one new active ingredient.** Hence, research costs should reflect the total cost incurred in synthesising, screening and testing of the appropriate number of products that you consider will lead to one successful product launch. For example, if your experience is that it is necessary to synthesise 40,000 molecules to discover one new crop protection product, then the research costs should reflect the total incurred for the synthesis and testing of 40,000 molecules.

Appendix 3: Study Questionnaire

Similarly if your company believes that for every new molecule registered there has to be X molecules going into the development process then the development costs should reflect the total expenditure on X. Please report expenditures before capitalisation. In addition, joint development needs to be clearly accounted for.

For the purposes of this study, biological crop protection products include microbials, natural products including those derived from fermentation, semiochemicals (such as pheromones) and biostimulants. The definition does not include biofertilisers or macrobials (e.g. insects/natural predators).

Part 2: Breakdown of R&D

Please provide the breakdown of total non-capitalised R&D expenditure in 2019. The regional split should be based on the market focus of the spending, and not where the money is spent. (e.g. where work is carried out in Europe to develop a product for the Central and South America market, this should be included in the Central and South America data).

Total R&D Expenditure: The total 2019 non-capitalised expenditure on all research and development activities relating to agrochemicals for both crop protection and non-agricultural uses. This covers R&D related to conventional crop protection in agriculture, pest control, industrial and consumer applications, public health and lawn and garden use. It also includes salaries and all other staff-related costs, as well as costs related to R&D administration, rent, supplies, equipment, materials, etc. Activities carried out (for the purpose of agrochemical development) within the corporation but outside the crop protection organization (for those companies having R&D centres/capacities outside of crop protection divisions) should also be included. Corporate research programs, expenditure on joint ventures, alliances, and research agreements with third parties should be included. Depreciation costs related to R&D assets should also be included. Capital expenditure on R&D is excluded.

Research of New Active Ingredients: Includes all of the R&D activities associated with the discovery of new agrochemical active ingredients up to the start of new product development.

Appendix 3: Study Questionnaire

Development of New Active Ingredients: Starts at the point when a company commits a new active ingredient to full development, generally marked by the decision to commence long-term toxicity tests. It ends with the registration and launch of a product in a major crop market (generally an OECD country).

Additional costs, Product Launch & Development: Incorporates all regulatory costs linked to product launch, label expansions and product defence (e.g. formulation development and field trials). It excludes all sales and marketing costs associated with the product launch.

Product Monitoring / Stewardship: All product development activities following the launch of a new active ingredient into a major market, including re-registration/registration maintenance: refers to any activities or studies that must be undertaken in response to the requirements of registration authorities in order to maintain a product's registration. Also includes activities required to satisfy regulatory requirements for registration in non-OECD countries, and line extensions of existing products.

Part 3: CODEX MRL Costs During 2014 - 2019

Please indicate costs associated with obtaining and maintaining a CODEX MRL (new active, additional/new use and periodic review) in the 2014 - 2019 time frame.

Part 4: Re-Registration Costs During 2014 - 2019

Please provide costs (including fees, studies etc.) for the re-registration of an active ingredient that was re-registered in the 2014 - 2019 time frame.

Appendix 3: Study Questionnaire

Study Questionnaire (Continued)

Company Information

All information provided by respondents will be anonymised, with all data in the final published report being mean values.

Please provide the name of the company and the currency used in responses to the questionnaire. Any non-US dollar currencies will be converted to US dollar using average yearly exchange rates.

Company Name	
Currency Used	

Appendix 3: Study Questionnaire

Part 1: Breakdown of R&D Expenditure for Bringing a Single New Active Ingredient to a Major Market in the 2014 - 2019 Time frame

Please provide indicative data for a product introduced around the 2014 - 2019 time frame

Activity Stage			Cost
Research	Chemistry	Synthesis	
		Formulation	
	Biology	Efficacy Testing (Glasshouse)	
		Small plot trials	
		Field trials	
	Toxicology	Mammalian acute	
		Mammalian sub chronic	
		Environmental	
	Environmental Chemistry	Metabolism	
		Residue analysis	
Development	Chemistry	Scale up of Manufacture	
		Formulation	
	Biology	Large Scale Field trials	
		Registration Field trials	
	Toxicology	Chronic Mammalian	
		Environmental	
	Environmental Chemistry	Metabolism	
		Residues	
Additional Costs – EU		Registration fees	
		Internal Registration Costs	
		Additional studies*	
Additional Costs - US		Registration fees	
		Internal Registration Costs	
		Additional studies*	

**Additional studies refer to specific studies that are only requested in the EU or US and have no use in any other country or registrations region*

Appendix 3: Study Questionnaire

Additional Costs

Any Additional R&D Costs Associated with New Product Development for a product introduced between 2014 – 2019 not Identified in Part 1.

Item	Cost

Development Lead Time

Item	Time
In your opinion please indicate the number of years between the first synthesis and the first sale of the product.	

Part 2: Breakdown of R&D Budget

		Research of New Active Ingredients	Development of Off Patent Products[2]	Development of New Active Ingredients[3]	Additional costs: Product Launch & Development[4]	Product Monitoring / Stewardship[5]
Total R&D Expenditure						
Spending by Sector	Chemical					
	Biologicals					
Market Focus of Spending[1]	Europe					
	North America					
	C&S America					
	Rest of the world					

1. The regional split should be based on the market focus of the spending, and not where the money is spent. (e.g. where work is carried out in Europe to develop a product for the Central & South America market, this should be included in the Central & South America data)
2. Development of off patent products new to your company
3. Regulatory costs would be covered under this heading – except data that is specifically related to product launch
4. This should include all regulatory costs linked to product launch, label expansions and product defence (e.g. formulation development and field trials). It excludes all sales and marketing costs associated with the product launch
5. As required by terms of registration

Part 3: CODEX MRL Costs 2014 - 2019

Please indicate costs associated with obtaining a CODEX maximum residue limit in the period 2014 - 2019

Item*		Cost
	New Active Ingredient	
	Per additional use	
	Periodic Review	

*Please indicate if the chosen active ingredient was a herbicide, insecticide or fungicide

Part 4: Re-Registration Costs During 2014 - 2019

Item*	Geography	Cost
	European Union	
	United States	
	Other Jurisdictions (please specify)	

*Please indicate if the chosen active ingredient was a herbicide, insecticide or fungicide

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