PhillipsMcDougall
AGROCHEMICAL & BIOTECHNOLOGY CONSULTANTS

R&D trends

for chemical crop protection products and the position of the European Market

A consultancy study undertaken for ECPA

Phillips McDougall, September 2013






Contents

A Consultancy Study undertaken by:

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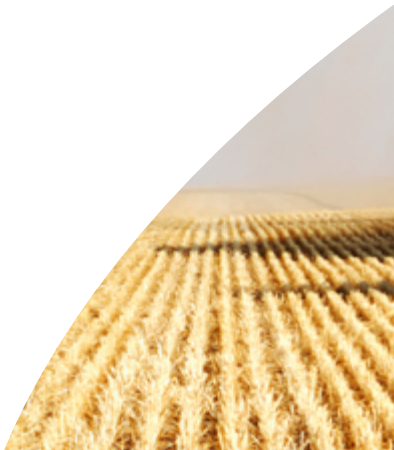


Summary

Overview of research and development

- The number of companies involved in the research and development of new agrochemical active ingredients worldwide has halved, from 34 companies in 1995 to 17 in 2012.
- Between 1995 and 2005, the cost of bringing a new active ingredient to market has risen from $152 million to $256 million.
- Since 2010 the total R&D expenditure devoted to seeds and traits R&D has exceeded that for agrochemicals.
- In 2000 there were 70 new active ingredients in the development pipeline; in 2012 there were only 28.

Market development

- Between 2003 and 2011 Europe was the leading regional agrochemical market worldwide; in 2012 it was overtaken by Asia.
- The European agrochemical market in terms of growth and sophistication is divided between EU-15, new EU-12 and East European markets.
- The focus of R&D is on the high value EU-15 markets. However, the EU-15 has recorded the slowest growth of all the regional agrochemical markets worldwide.

Decreased R&D investment for the European market

- The global share of new agrochemicals focussed on the European market has fallen from 33.3% in the 1980s to 21.3% in the 1990s to 16.4% in the 2005-14 period.
- The share of crop protection R&D investment attributable to products being developed for the European market has fallen from 33.3% in the 1980s to 25.0% in the 1990s to 7.7% in the 2005-14 period.
- The key reasons behind the reduction in R&D investment in crop protection products for the European market are:-
  - The mature nature of the EU-15 market
  - The non-acceptance of GM technology
  - The harsh regulatory environment
- European farmers have far less new technology to drive agricultural production than their competitors in other regions of the world.

Background to the report

Phillips McDougall has been asked to investigate recent trends in research and development in the crop protection sector, specifically as it influences the level of investment in and focus on the European market.

Methodology

The analysis presented in this report is based on the following sources of information:

Global market information developed and published by Phillips McDougall in the AgriService since 1999, a global analysis of the Agrochemical and GM trait industries, containing market data back to 1980. The AgriService is subscribed to by all the leading Crop Protection companies and Investment Banks worldwide. All data is presented at the ex-manufacturer level, i.e. from companies to the first step of distribution, or direct to farmers in some instances.

Introduction

In the recent past there have been a number of major factors that have affected R&D into conventional chemical crop protection products. This has been due to a variety of factors, from an increasingly harsh regulatory environment to the increasing costs of bringing a new product to market (Table 1).

Factors Affecting Agrochemical R&D Expenditure

- Harsh regulatory environment
- Increasing cost of new active ingredient R&D
- Industry consolidation
  - Fewer companies involved
- Increasing expenditure to defend off-patent molecules
  - Development of defining technologies
    - > Formulations
    - > Seed treatments
- Shift in R&D expenditure to seeds and GM traits

Agriculture is a global industry, but a number of regional factors affect the focus of R&D, including commercial market development or the opportunity for innovation. These are related to the key crops grown in a region, the corresponding pest weed and disease control requirements and the level of control offered by existing products on the market.

Companies involved in new Active Ingredient research

Table 1 shows that worldwide the number of companies involved in the research and development of new active ingredients has halved from 35 companies in 1995, to 18 in 2012. This has affected competition in the new product area and the diversity of products that have been developed.

In addition, there are a number of small, often start-up companies involved in technology development. Figure 1 shows the cost of bringing a new active ingredient from discovery through to market introduction. The majority of these small companies do not have the financial capability of bearing such costs; as a result the major way for products developed by these companies to get to market is for the product, the company or both, to be acquired by one of the major companies in the industry.

A number of analogues of existing chemistry are also in development in China, however as none of these has a complete GLP (Good Laboratory Practice) data package, then any company licencing in any of this technology would have to repeat many of the studies required for registration, but under GLP conditions. The cost of this would be similar to the development costs (Figure 1), as a result, to date, only one product from this source has been brought forward for development outside China, and this is by a US based company.

Table 1: *Companies involved in New Active Ingredient Research*

Year	Europe	USA	Japan
2012	Bayer	Dow AgroSciences	Sumitomo Chemical
	Syngenta	DuPont	Ishihara
	BASF	Chemtura	Nihon Nohyaku
	Isagro		Otsuka
			Mitsui Chemical
			Kumiai
			Hokko
			Meiji Seika
			Nippon Soda
			Agro Kanesho
			Nissan
Number of companies 2012	4	3	11

Year	Europe	USA	Japan
1995	Bayer	Dow	Sumitomo Chemical
	Hoechst	Eli Lilly	Ishihara
	Schering	DuPont	Nihon Nohyaku
	Rhone Poulenc	Cyanamid	Otsuka
	BASF	Uniroyal (Chemtura)	Mitsui Toatsu
	Ciba Geigy	Valent	Sankyo
	Sandoz	Monsanto	Hodogaya
	Zeneca	FMC	Chugai
		Rohm & Haas	Kumiai
		Merck	Hokko
		Abbott	Meiji Seika
			Nippon Soda
			Agro Kanesho
			Shionogi
			Takeda
			Nissan
Number of companies 1995	8	11	16

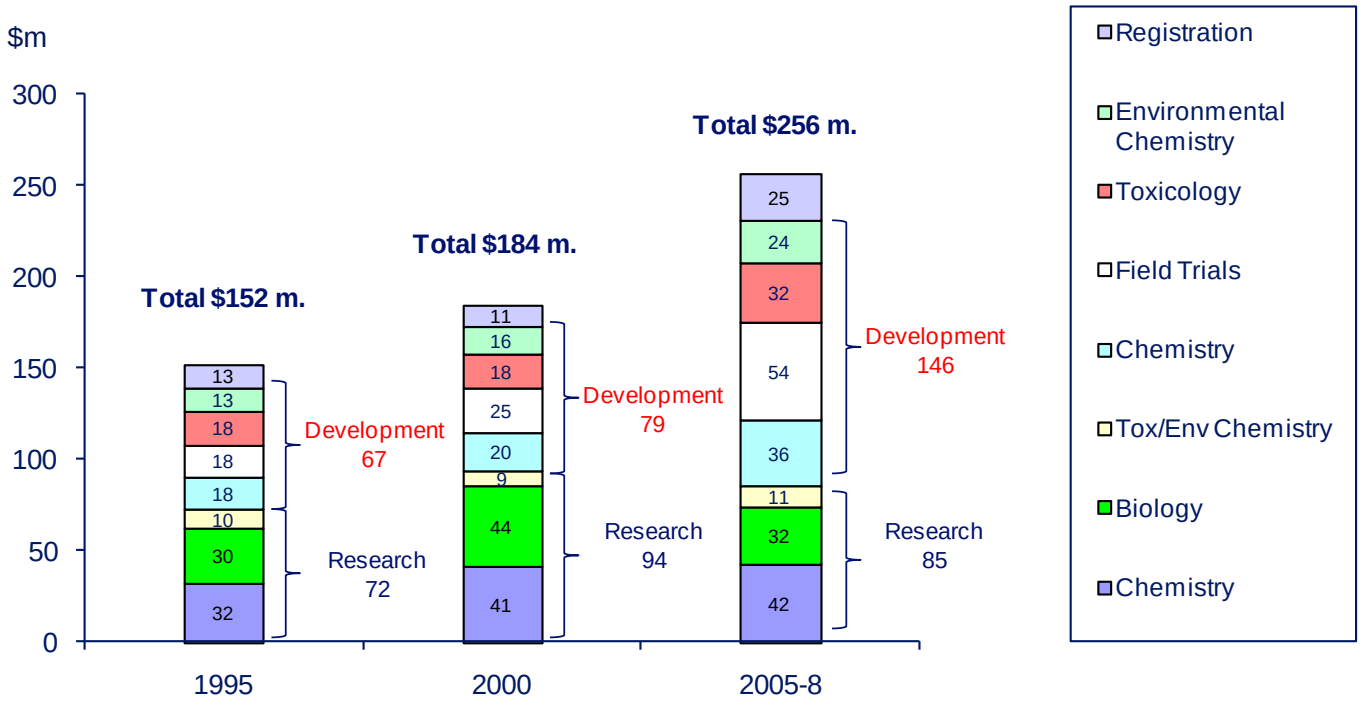
The increased cost of bringing a new Active Ingredient to the market

Figure 1 shows the average of the expenditure of all the major R&D driven companies to bring a new active ingredient to the market. The most recent data is based on the 2005-2008 timeframe as each of the major companies introduced a significant product in that period, so each would have data on which to base its response to the questionnaire.

Between 1995 and 2005, the cost of bringing a new active ingredient to market has risen on average by 68.4%, research costs have risen by 18.0%, but development costs by 117.9%. Research relates to chemical synthesis and product discovery as well as screening to prove activity, initial toxicology and environmental chemistry screens will also be undertaken to ensure sufficient safety of the potential product. Development relates predominantly to the studies required to achieve registration, clearly this is where the greatest increase in cost has occurred.

As development costs are so high, it is a major decision by the company whether to progress a potential new active ingredient from the research phase into development. Once started this investment has been committed, as many studies cannot be halted once started. To progress a product into development the company must have a reasonable certainty that it will achieve registration, and also of commercial success once introduction has been achieved. It is now most unusual for a product entering development to not progress to market introduction.

Figure 1: *The increasing cost of bringing a new Active Ingredient to the market**



* Results of a study undertaken for ECPA and CropLife America

Breakdown of R&D Budgets 2007 and expectation for 2012

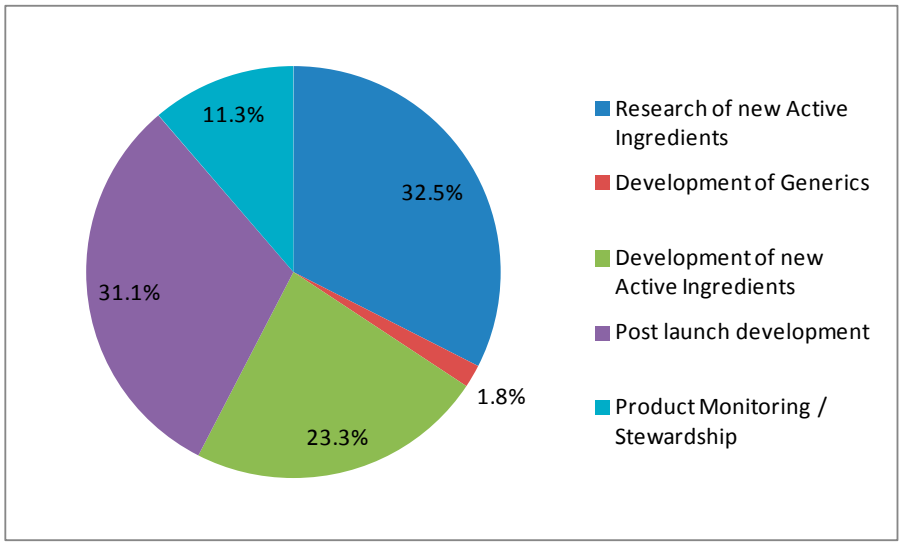
Whilst the first part of the study covered the cost of bringing a new active ingredient to market, the second part covered the current breakdown of the R&D budget and how this was expected to alter in the future.

Between 2007 and 2012 (Figure 2), total agrochemical R&D expenditure of the major companies was expected to increase by 26.4% to $2.94 billion. However, the share of this expenditure on the research of new active ingredients was expected to fall from 32.5% to 29.6% (although in actual dollar terms this is a 15% increase). The share of expenditure due to Development of new active ingredients was expected to rise from 23.3% to 24.9%, in line with the increasing requirements of regulatory bodies (in actual dollar terms a rise of 35%). Of greater significance was the intended increase in post launch development, from 31.1% to 31.4% (up 28% in actual dollar terms).

Post launch development relates to further introductions in minor country or crop markets, new formulation development including usage in mixtures with other active ingredients and in seed treatments. All of these form part of post patent product sales protection strategies.

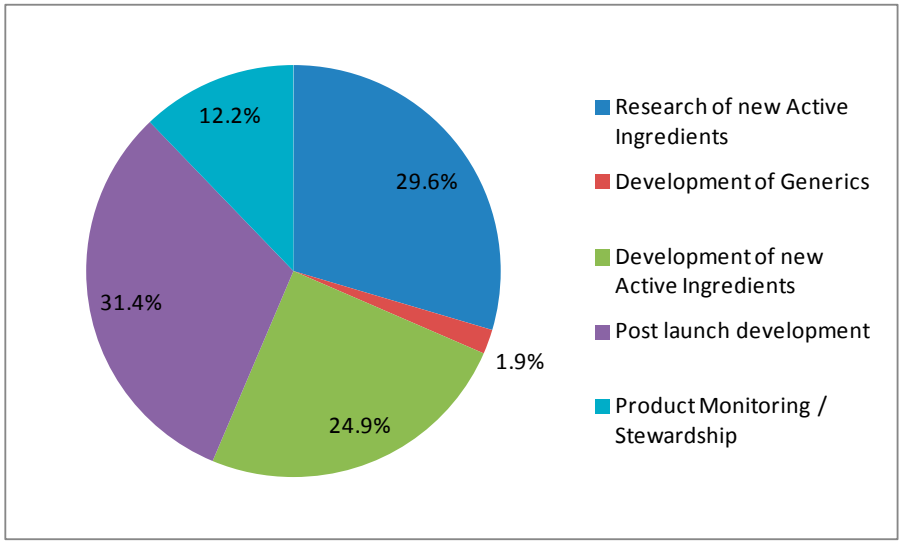
As the rate of new product introduction slows, it is evident that a greater proportion of the R&D budget was expected to be spent on trying to maximize the sales of products when they suffer patent expiry, rather than on new active ingredient research.

Figure 2: *Breakdown of R&D budgets 2007 and expectation for 2012 (study performed in 2008)**



2007 (actual)

Total = $2,328 million



2012 (expected)

Total = $2,943 million

* Results of a study undertaken for CropLife America

Swing of Overall R&D Expenditure toward Seeds and Traits

Figure 3 shows the R&D expenditure of the leading agrochemical companies, which are now also the leading companies in the Seeds industry. It clearly shows that R&D investment in the seeds and traits area is growing at a faster rate than for agrochemicals, with the total R&D spend on seeds and traits exceeding that on agrochemicals since 2010.

The driving force behind the increase in seeds R&D is the development of new GM traits, a technology that has only been accepted in the EU in the most limited way. The adoption of GM technology also has an impact on the requirements for chemical crop protection on these crops. The impact of this is not only that GM trait development draws R&D investment away from the EU market, but also that the development of agrochemicals to provide a complete offering around the GM seed also draws agrochemical R&D investment away from the EU market.

Timeline for new GM Trait introductions

Currently the key focus for GM trait adoption (Figure 4) has been in the Americas, principally the USA, Argentina, Canada and Brazil, although increasing acceptance in Asian markets is anticipated.

It is evident that the development of the seed treatment market has coincided with the adoption of GM seed, with farmers wishing to protect high priced GM seed from the minute that it is planted. The GM traits incorporated into the plant will only protect against some insect pests, with other pests and disease needing to be controlled by conventional chemical crop protection technology. The easiest and most labour efficient means of doing this is by treating the seed.

Although seed treatment is also widely used in Europe on conventional crops, the focus for new developments has been seed treatment for crops containing GM traits, which has again drawn R&D investment away from European markets.

Figure 3: *Swing of overall R&D expenditure towards seeds and traits*

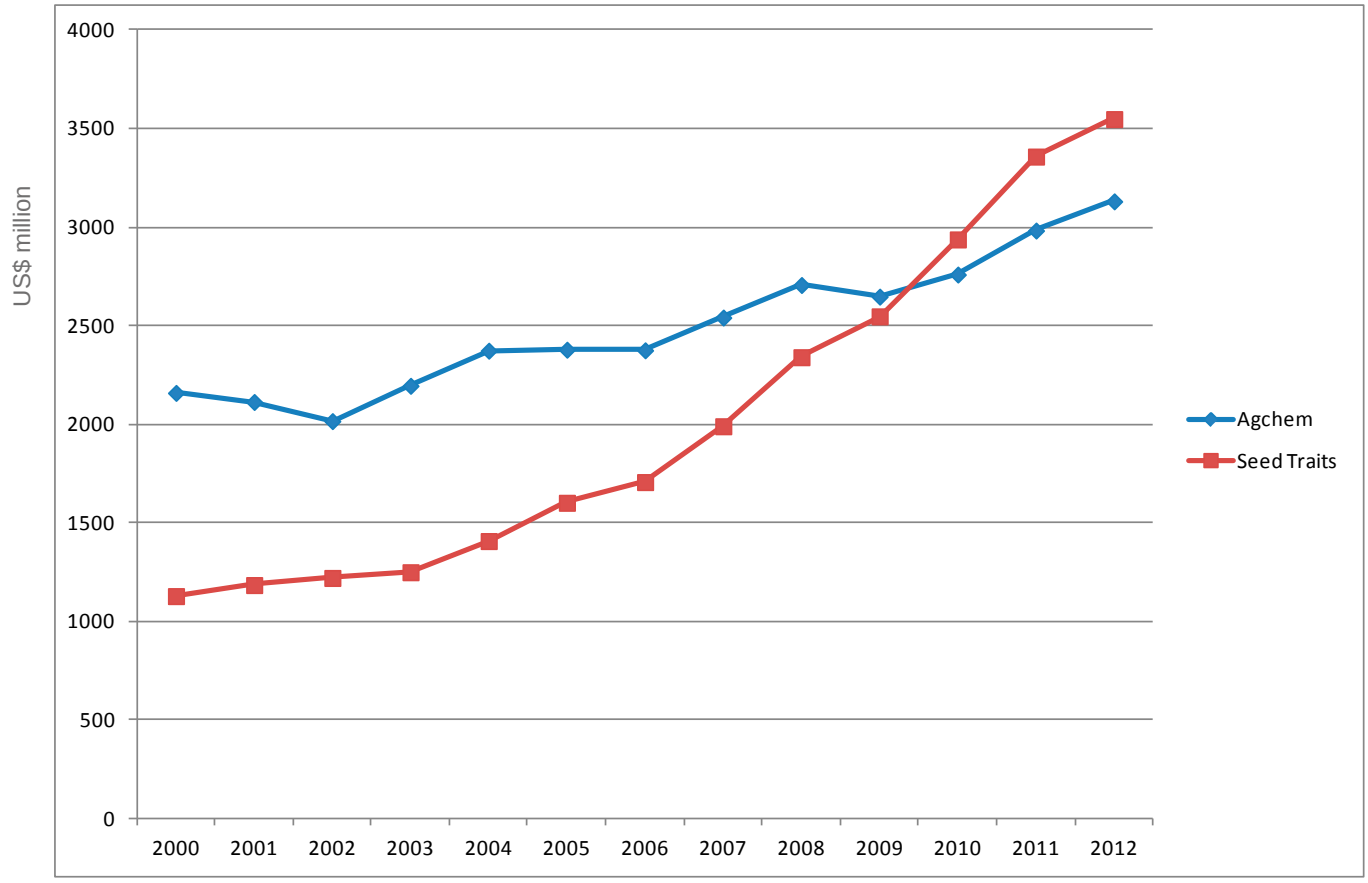
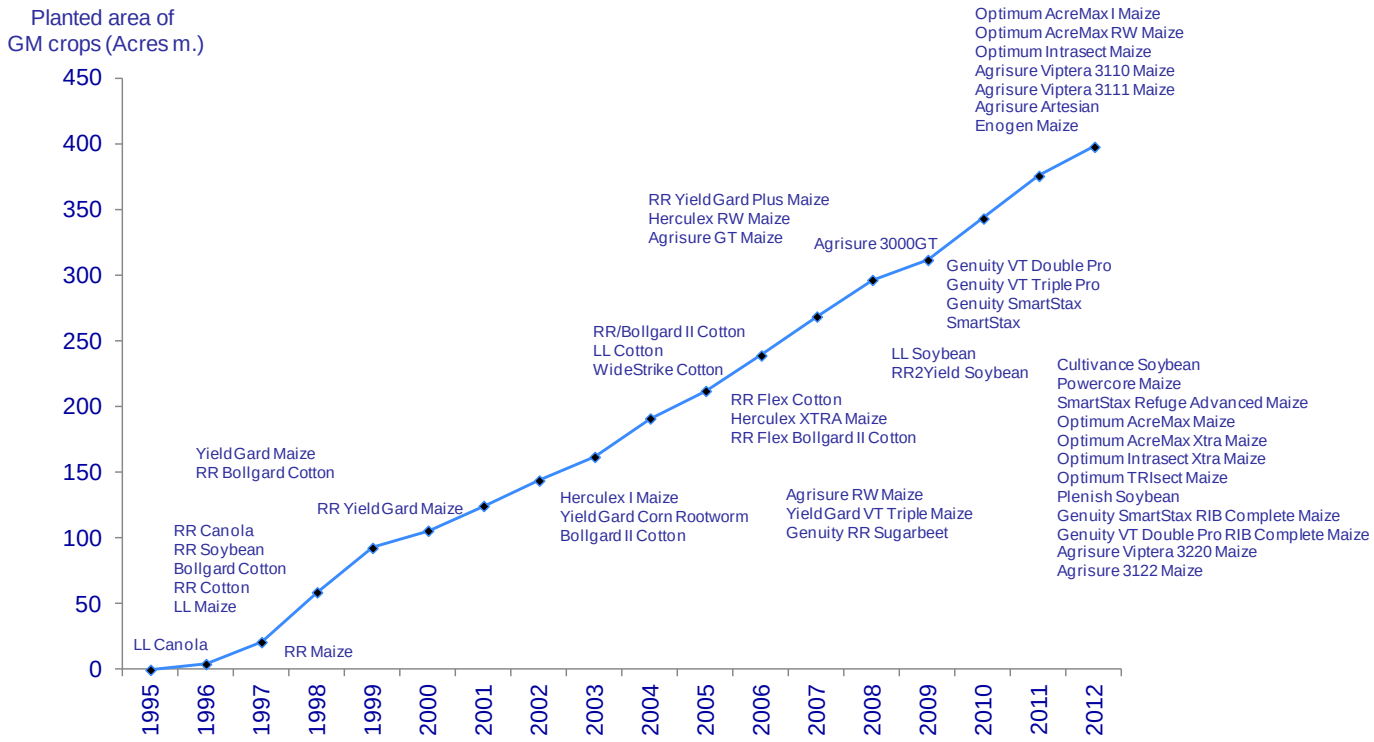


Figure 4: *Timeline of new GM trait introductions*



New Agrochemical Active Ingredient Introductions Since 1950

Figure 6 clearly shows that worldwide the number of new introductions per year has been in a trend of decline since 1997.

Agrochemical Active Ingredients in Development

Figure 5 shows a more concerning pattern, in that the number of new active ingredients in development has shown a more significant fall. In 2000, there were 70 new active ingredients in the development pipeline, in 2012 there were only 28.

Figure 5: *Agrochemical Active Ingredients in development*

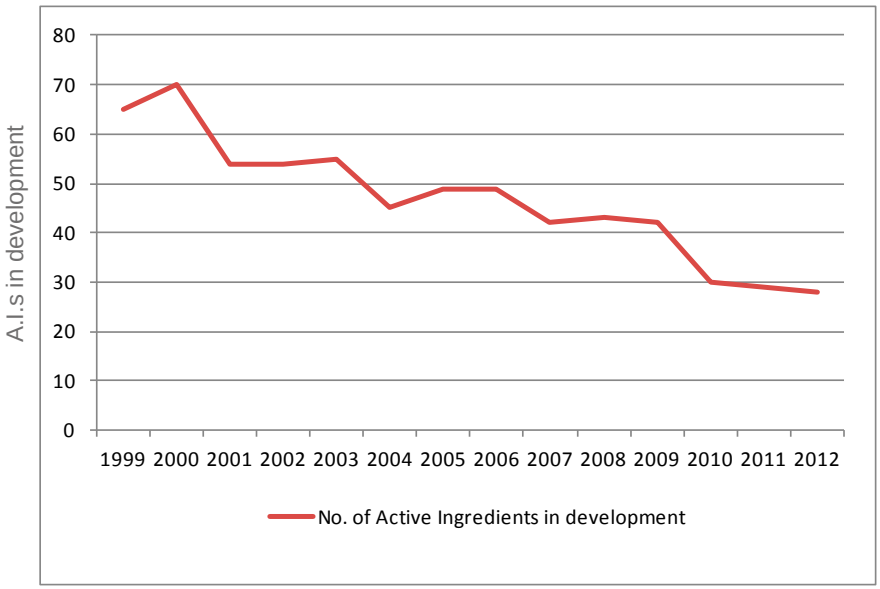
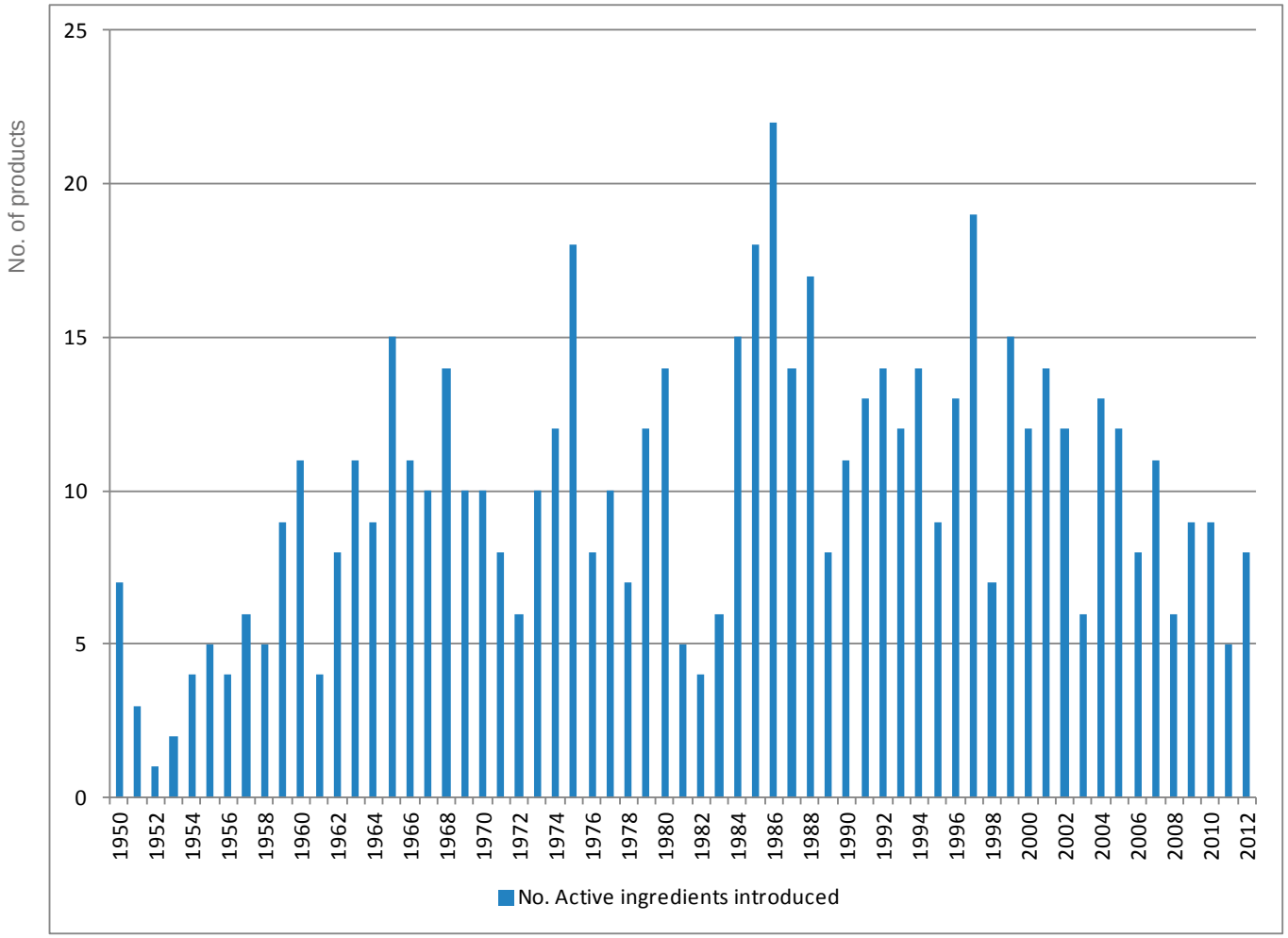


Figure 6: *Agrochemical Active Ingredient introductions since 1950*



Market Development

Regional Chemical Crop Protection Market Development

In 2012, Asia overtook Europe to become the largest regional market worldwide. Table 2 clearly shows that the greatest market expansion in value terms in both the last 5 and 10 year periods has occurred in the developing markets of Asia and Latin America.

The growth of the NAFTA market has been held back by the shift to GM solutions for crop protection (Figure 7).

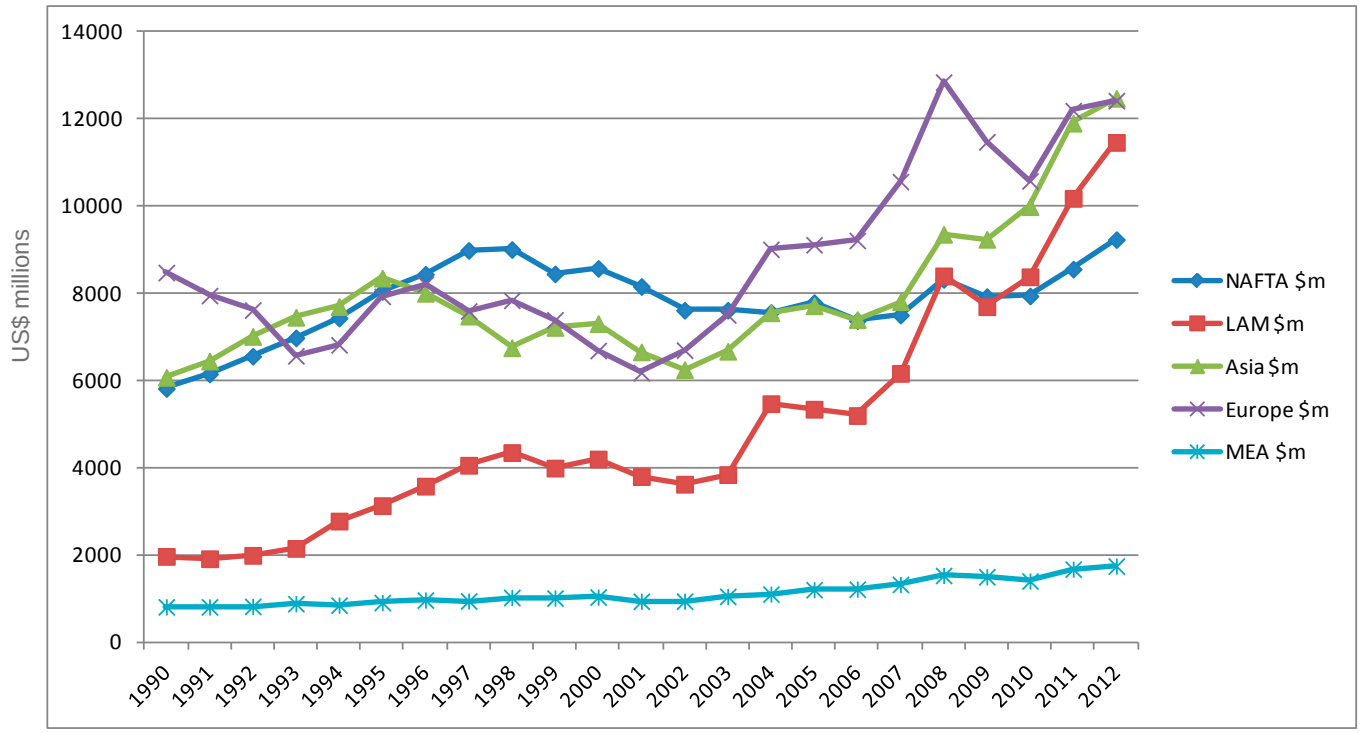
Compound annual growth rate of the regional crop protection markets

The European market for conventional chemical crop protection products divides between three distinct areas, the developed, mature EU-15 markets, the developing new members of the EU where market development is assisted by increasing investment in agriculture (the new EU-12), and then the non-EU European countries, which include the developed Swiss and Norwegian markets (although these are relatively mature with limited growth potential), but more importantly the rapidly developing markets in Russia, the Ukraine and other East European countries.

Table 2: *Compound annual growth rate of the regional crop protection markets (% p.a.)*

	2012 / 2007	2012 / 2002
Asia	9.8	7.1
Latin America	13.2	12.2
Europe	3.3	6.4
NAFTA	4.2	1.9
Middle East & Africa	5.7	6.4
World	7.2	6.5

Figure 7: *Regional chemical crop protection market development*



European crop protection market by sector

In Figure 8 it can clearly be seen that the greatest growth in the European crop protection markets has been recorded by the 'Rest' of Europe, predominantly Russia and the Ukraine, followed by the 'New' EU-12, led by Poland, the Czech Republic and Hungary. Less growth has been recorded by the developed EU-15 markets (Table 3).

European Crop Protection Market by Crop 2012

The key European market for crop protection products, and the main focus for R&D, is cereals (Figure 9). The next major crop is maize; however R&D in this area has been reduced due to the shift of this market in the Americas to genetic solutions. The next major row crop is oilseed rape, however few agrochemicals are developed specifically for use on the crop, most being adaptations of products developed for use on other crops. The other leading crops are all in the diverse fruit & vegetables sector.

From an R&D perspective, the driver of new product development for the EU-15 markets is improved solutions for existing problems, particularly where pest, weed or disease resistance has become an issue. Generally the level of technical sophistication is not as high in the new EU-12 markets, although increasing investment and farmer wealth is driving market development toward newer, more efficacious products. The lesser developed markets generally utilise more basic solutions based on products that have been on the market for some time.

A good example of this is the cereal fungicide sector, a key focus for new active ingredient development for the European market, where the level of market sophistication relates directly to how recently the major products utilised have been introduced and adopted (Table 4).

Table 3: *Compound annual growth rate of the European crop protection market (% p.a.)*

	2012 / 2007	2012 / 2002
EU 15	2.8	1.7
New EU 12	6.2	4.2
Rest of Europe	14.8	10.1

Figure 8: *European crop protection market by sector*

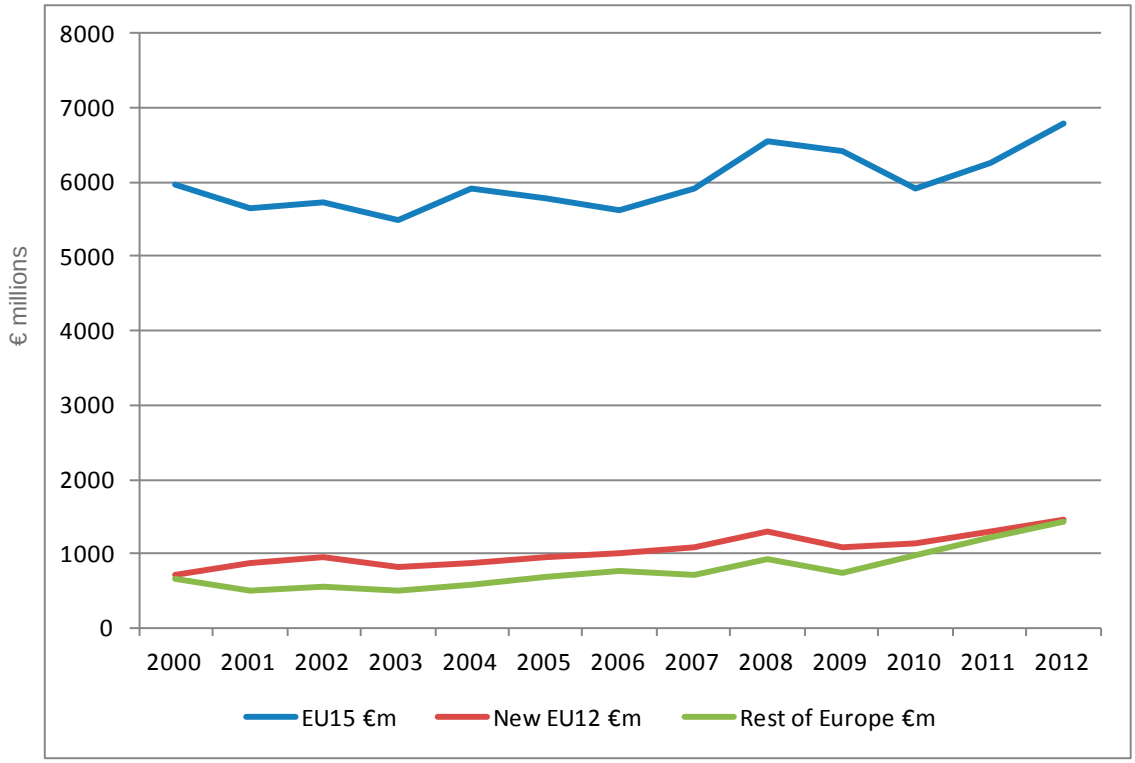
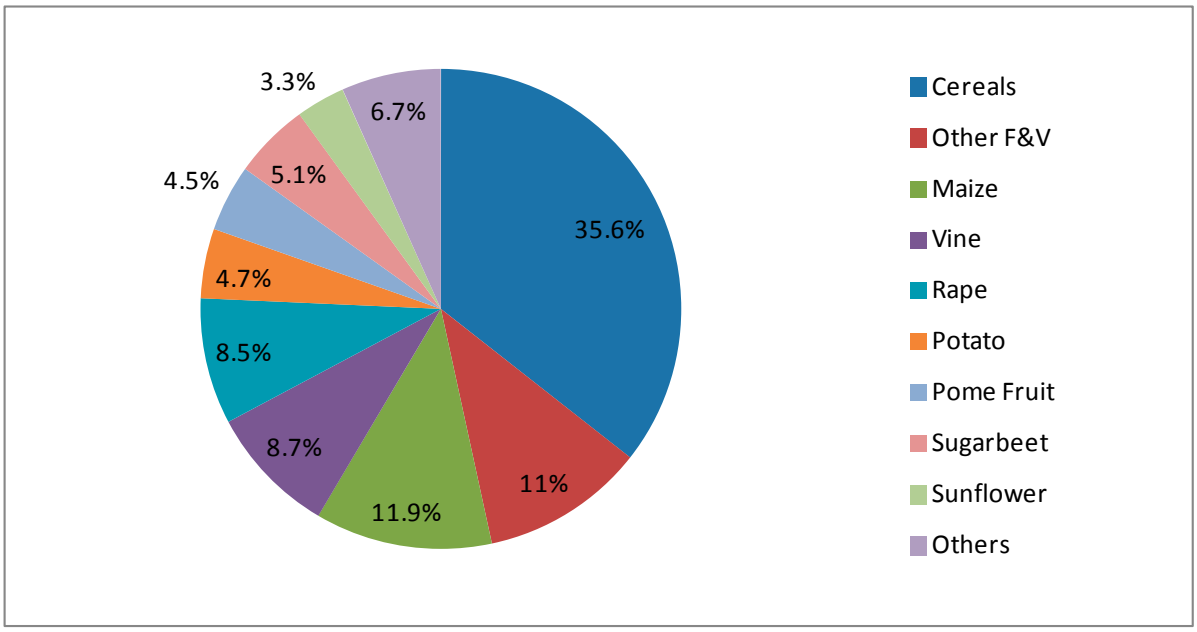


Figure 9: *European crop protection market by crop 2012*



Cereal Fungicide Introductions

The inference from the analysis presented above is that the focus for new product development in Europe is cereals for the major developed markets in the EU-15, however in the European market it is these country markets that have recorded the least growth over the last five and ten year periods. Figure 8 shows that the European market has enjoyed periods of strength in 2008 and again in 2011 and 2012. These times correspond with periods when the global price of cereals was strong, predominantly due to poor global harvests in the previous years, resulting from poor weather conditions.

The relatively low growth in the EU-15 countries, coupled with the susceptibility of the market to weather impacts and cereal prices, limits its attraction as a focus for R&D investment. When this is taken into account alongside the current regulatory regime in the EU, the risks involved in new active ingredient development for the EU market result in an environment where investment will be limited.

Table 4: *Cereal fungicide introductions*

Level of sophistication	Major products (date of introduction)	Country
Basic	mancozeb (1943), chlorothalonil (1963),carbendazim (1973)	
Early development	1st generation triazoles: propiconazole (1980), triadimenol (1980)	Bulgaria, Romania
Developing	3rd generation triazoles: cyproconazole (1988), tebuconazole (1988), epoxiconazole (2003)	Russia, Ukraine
Highly developed	Strobilurins: kresoxim (1996), azoxystrobin (1997), trifloxystrobin (2000), pyraclostrobin (2002)	Czech Republic, Poland, Slovakia, Croatia
Advanced	SDHI products: bixafen (2010), isopyrazam (2010), sedaxane (2011), fluopyram (2012), penflufen (2012)	France, Germany, UK

Regulatory Environment

Principles of 1107/2009

The key issue from the new regulation (1107/2009) governing the registration and re-registration of agrochemical products in the EU, is that the criteria for approval is now governed by an initial assessment of hazard in addition to the assessment of risk. This effectively negates scientifically based argument regarding the relative toxicity of substances.

A product will not achieve registration or re-registration if it is deemed to be mutagenic, carcinogenic, or potentially in the future, an endocrine disruptor, regardless of the level of the offending compound that may be encountered. Under the previous legislation, if the expected exposure level that may be encountered following correct application was minimal and well within safety limits, then the risk was deemed acceptable and the active ingredient could be registered or re-registered.

Under 1107/2009, any exposure, regardless of level, is deemed unacceptable when a substance triggers the hazard criteria and the product will not be registered, or it will be refused re-registration.

This situation is expected to have a further negative impact on the number of active ingredients that are likely to be developed for the EU market. As stated above, a key decision for companies developing new active ingredients is whether to progress the products from research into development, as the development stage is where the greatest level of expenditure has to be made.

Under the previous criteria, if the product under development was deemed to be mutagenic or carcinogenic, then an assessment of potential exposure could be made and if this was within safety limits then the product may well progress into development, on the understanding that the potential risk was acceptable and that registration would probably be achieved.
Under the new criteria, and with the level of investment required to take a new active ingredient through the development process, if there is the slightest concern regarding the product under development and there is a possibility that following development registration will not be achieved, then it is most unlikely that a company would progress such a product into the development process. The eventual inclusion of endocrine disruption into these criteria is likely to result in even fewer products entering development.

Research and Development

Trend Analysis

A review of new active ingredients introduced to the market and those in R&D has been made to ascertain the focus of research and development on products for the European market. The number of products introduced between 1980 and 1989 has been compared with the ten year period from 2005 through to 2014 (both products introduced and those in R&D) (Table 5).

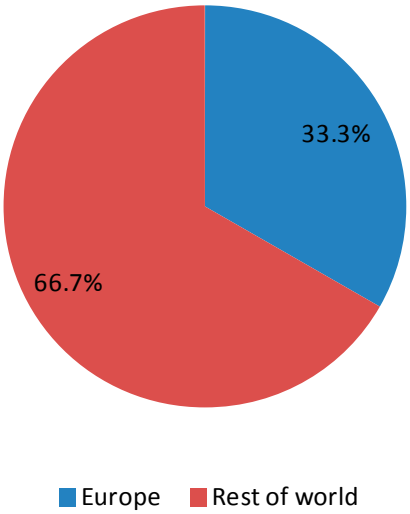
Between the 1980s and the 2005 to 2014 period, the number of active ingredients introduced and in development has fallen by 40.7%, in line with the falling number of products in development highlighted earlier in this report. However, the proportion of these active ingredients focussed on the European market has fallen from 33.3% to only 16.4% between these two periods, a decline of 70.7% (Figure 10).

Table 5: *Regional focus of Active Ingredients introduced and those in development*

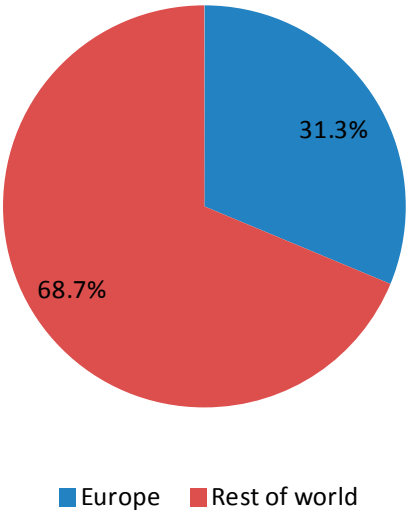
Region	1980 - 1989	1990 - 1999	2005 - 2014
Worldwide	123	128	73
Europe	41	40	12
Share Europe (%)	33.3	31.3	16.4

Figure 10: *Share of Active Ingredients introduced or in development*

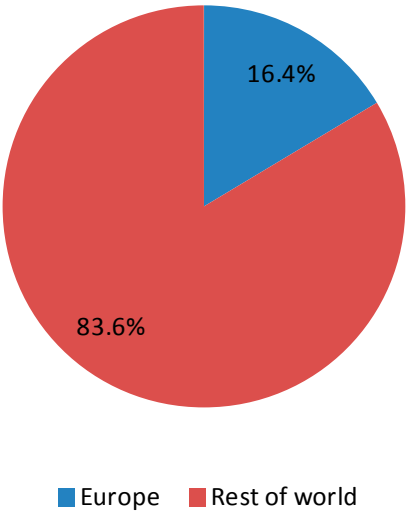
1980 - 1989
Total = 123 Active Ingredients



1990 - 1999
Total = 128 Active Ingredients



2005 - 2014
Total = 73 Active Ingredients



Breakdown of R&D investment

Between 1995 and 2012 the sum of company expenditure on crop protection R&D worldwide, including on GM traits to confer crop protection, more than doubled from $3,060 million to $6,711 million (Table 6). However, the proportion of that expenditure that can be attributed to products being developed for the European market declined from 25.0% of the total to only 7.7%.

Assuming that the % of sales spent on R&D was similar in 1985 as in 1995, this shows a continuation of a trend of declining investment on crop protection R&D for the European market since the 1980 to 1989 period. This is depicted in Figure 11.

Share of crop protection focussed R&D

In the 1980s, 33.3% of crop protection R&D could be attributed to product development for the European market, however by the 2005 to 2014 period this figure has fallen to 7.7% (Figure 11).

It is believed that a number of factors have contributed to reduced investment in research and development of new agrochemical active ingredients specifically for the European market.

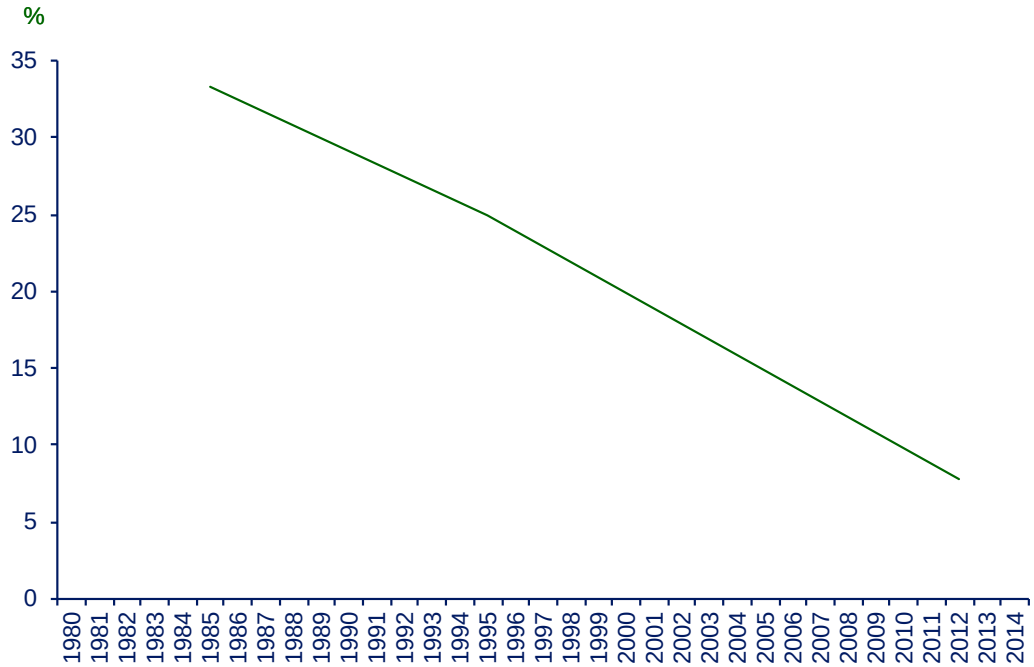
Table 6: *Breakdown of R&D investment*

	1980 - 1989	1990 - 1999	2005 - 2014
New Active Ingredient (A.I.) Introductions	123	128	73
New A.I.s targeted at Europe	41	40	12
% New A.I.s targeted at Europe	33.3	31.3	16.4
Chemical crop protection R&D spend $m	1271*	2450	3163
Europe R&D spend $m	424	766	520
Total R&D spend (Inc. GM) $m	1271	3060	6711
% Total R&D on new A.I.s for Europe	33.3	25.0	7.7

	1985	1995	2012
Crop protecton market $m	14,774	28,390	47,360
CP R&D % of market	8.6**	8.6	6.7

* Estimated based on assumed share
** Assumed same share as in 1995

Figure 11: *Share of crop protection R&D focussed on Europe*



Key Factors Affecting R&D Investment for the European Market

- Mature nature of EU-15 markets
- Attraction of developing markets driven by volume growth
- Non acceptance of GM seed
- Shift in investment to seeds & traits R&D for non-European markets
- Investment in agrochemical R&D to support the GM seed sector
- Harsh European regulatory environment
- Re-registration procedure from 1991
- Hazard based assessment from 2011

The overall impact of this is that the European farmers have far less new technology to drive agricultural production than their competitors in other regions of the world. The European farmer cannot utilise GM seed technology and whilst in the 1980s and 1990s was enjoying a rate of new agrochemical introduction of 4.1 and 4.0 per annum, in the 2005 to 2104 timeframe this rate will fall to 1.2 per annum.

Discussion

The analysis has shown that the number of active ingredients being developed and introduced, with their primary target being the European crop protection market, is in decline.

On a global basis, the number of agrochemicals in development is falling, primarily due to fewer companies being involved, a greater focus by these companies on the seeds and traits area and a greater share of R&D investment being spent on defending products as they come off patent, including seed treatment and formulation technologies. Despite this, the rate of decline in the number of introductions focussed specifically on the European market is greater than that on a global basis.

For eight years in the 2000s, Europe was the largest regional agrochemical market worldwide, being overtaken by Asia in 2012. At this level the market should have been attracting a high level of agrochemical R&D interest, particularly as the adoption of GM crops in the region has been very limited. However, the reverse is true.

Analysis of the European market shows that the majority of the growth in agrochemical sales in the region has been driven by East European markets and the new EU-12. These markets are not as sophisticated as those in the EU-15, often relying on existing chemistries rather than the most recent technology. Growth in East European and EU-12 markets is a mix of greater intensity of product usage as farmer wealth increases and a trading up to more advanced higher priced agrochemicals, but seldom the most recent introductions. As a result, these countries have not been drivers for R&D investment.

The focus for new agrochemical R&D in Europe has been the high value but more mature EU-15 markets, however the growth in sales of agrochemicals in these countries has been far less significant. The maturity of these markets and the intensity of agricultural production results in resistance development by pests, weeds and diseases being a key factor, which makes them open to the acceptance of new technology to solve these problems.

Much of the growth that has been recorded in these countries can be attributed to value from the adoption of newer, higher priced agrochemicals. Over the last five years, in dollar terms, the EU-15 market has grown by only 1.5% p.a., slower than any of the other regional markets. As a result, despite the need for new technology to combat weed, pest and disease resistance, the chance for commercial success in the EU-15 is limited.

This weak commercial environment coupled with the severe regulatory requirements, which now include an initial evaluation of hazard, leads to a situation where the risk to the R&D company in developing active ingredients for the European market is now supressing innovation. The initial risk being that a high level of expenditure has to be made to develop a new active ingredient, however if registration is not achieved then this investment is lost. Secondly, the limited financial return from new active ingredient introductions, reducing the potential to recover this investment in R&D.

The non-acceptance of GM technology and the harsh regulatory environment has resulted in the focus of R&D no longer being on European markets, with the result that the share of global crop protection investment in R&D focussed on products for use in European markets has fallen from 33.3% in the 1980s to only 7.7% in the 2005 to 2014 period.

Agriculture and agrochemicals are global industries, in no other country outside the EU is the agrochemical registration system so severely regulated by hazard based assessment.

The potential for successful registration and commercial return is at less risk in non-EU, hence when R&D projects are being prioritised within companies, the focus for investment is likely to be outside the EU.

Appendix 1

Focus of products introduced between 1980 and 1989

No. Year	Sector	Active Indredient	Region	Crop
1 - 1980	Fungicide	propiconazole	Europe	Cereals
2 - 1980	Fungicide	triadimenol	Europe	Cereals
3 - 1980	Fungicide	prochloraz	Europe	Cereals
4 - 1980	Fungicide	fenpropimorph	Europe	Cereals
5 - 1980	Fungicide	fuberidazole	Europe	Cereals
6 - 1980	Fungicide	diclobutrazol	Europe	Cereals
7 - 1980	Herbicide	benfuresate	Europe	Cereals
8 - 1981	Fungicide	fenitropan	Europe	Cereals
9 - 1982	Fungicide	benalaxyl	Europe	F&V
10 - 1983	Fungicide	oxadixyl	Europe	F&V
11 - 1983	Fungicide	penconazole	Europe	F&V
12 - 1983	Insecticide	clofentezine	Europe	Apples
13 - 1984	Fungicide	flutriafol	Europe	Cereals
14 - 1984	Herbicide	metsulfuron	Europe	Cereals
15 - 1984	Herbicide	isoxaben	Europe	Cereals
16 - 1984	Insecticide	fluvalinate	Europe	many
17 - 1984	Insecticide	furathiocarb	Europe	many
18 - 1985	Fungicide	fenpropidin	Europe	Cereals
19 - 1985	Herbicide	fluroxypyr	Europe	Cereals
20 - 1985	Herbicide	diflufenican	Europe	Cereals
21 - 1985	Herbicide	tribenuron	Europe	Cereals
22 - 1985	Herbicide	flurochloridone	Europe	Sunflower
23 - 1985	Insecticide	fenoxycarb	Europe	F&V
24 - 1986	Fungicide	flusilazole	Europe	Cereals
25 - 1986	Fungicide	hexaconazole	Europe	F&V
26 - 1986	Fungicide	chlozolinate	Europe	F&V
27 - 1986	Fungicide	pyrifenox	Europe	F&V
28 - 1986	Herbicide	tralkoxydim	Europe	Cereals
29 - 1986	Herbicide	imazamethabenz	Europe	Cereals
30 - 1986	Herbicide	ethiozin	Europe	Cereals
31 - 1986	Herbicide	fluoroglycofen	Europe	Cereals
32 - 1987	Fungicide	triflumizole	Europe	Cereals
33 - 1987	Herbicide	triasulfuron	Europe	Cereals
34 - 1987	Herbicide	aclonifen	Europe	Sunflower
35 - 1987	Herbicide	cycloxidim	Europe	BL crops
36 - 1988	Fungicide	tebuconazole	Europe	Cereals
37 - 1988	Fungicide	myclobutanil	Europe	Cereals
38 - 1988	Fungicide	cyproconazole	Europe	Cereals
39 - 1988	Fungicide	fenpiclonil	Europe	Cereals
40 - 1988	Herbicide	prosulfocarb	Europe	Cereals
41 - 1989	Fungicide	difenoconazole	Europe	F&V
42 - 1982	Herbicide	fomesafen	Americas	Soybean
43 - 1983	Other	flumetralin	Americas	Tobacco
44 - 1980	Insecticide	fenpropathrin	Asia	many
45 - 1983	Herbicide	anilofos	Asia	Rice
46 - 1984	Herbicide	bensulfuron	Asia	Rice
47 - 1984	Herbicide	pretilachlor	Asia	Rice
48 - 1984	Insecticide	buprofezin	Asia	Rice
49 - 1986	Herbicide	mefenacet	Asia	Rice
50 - 1986	Herbicide	bromobutide	Asia	Rice
51 - 1987	Herbicide	cinmethylin	Asia	Rice
52 - 1988	Fungicide	pencycuron	Asia	Rice
53 - 1988	Fungicide	diniconazole	Asia	Cereals
54 - 1988	Herbicide	quinclorac	Asia	Rice
55 - 1988	Herbicide	clomeprop	Asia	Rice
56 - 1988	Other	uniconazole	Asia	Rice
57 - 1980	Insecticide	cyfluthrin	Global	many
58 - 1981	Herbicide	sethoxydim	Global	BL crops
59 - 1982	Herbicide	chlorsulfuron	Global	Cereals
60 - 1983	Insecticide	alpha-cypermethrin	Global	many
61 - 1984	Insecticide	lambda-cyhalothrin	Global	Many
62 - 1985	Herbicide	quizalofop	Global	BL crops
63 - 1985	Insecticide	abamectin	Global	Many
64 - 1985	Insecticide	cyromazine	Global	F&V
65 - 1985	Insecticide	hexythiazox	Global	F&V
66 - 1985	Other	paclobutrazol	Global	F&V
67 - 1986	Herbicide	glufosinate	Global	Many
68 - 1986	Insecticide	esfenvalerate	Global	Many
69 - 1986	Insecticide	bifenthrin	Global	Many
70 - 1986	Insecticide	teflubenzuron	Global	Many
71 - 1988	Fungicide	fluazinam	Global	Potato
72 - 1988	Herbicide	primisulfuron	Global	Maize
73 - 1988	Insecticide	cadusafos	Global	F&V
74 - 1989	Herbicide	flazasulfuron	Global	F&V
75 - 1989	Insecticide	chlorfluazuron	Global	F&V
76 - 1989	Insecticide	flufenoxuron	Global	F&V
77 - 1980	Fungicide	mepronil	Japan	Rice
78 - 1980	Herbicide	naproanilide	Japan	Rice
79 - 1980	Herbicide	butamifos	Japan	F&V
80 - 1981	Fungicide	probenazole	Japan	Rice
81 - 1981	Insecticide	flucythrinate	Japan	F&V
82 - 1984	Fungicide	flutolanil	Japan	Rice
83 - 1984	Fungicide	iminoctadine	Japan	Rice
84 - 1984	Fungicide	methasulfocarb	Japan	Rice
85 - 1984	Herbicide	bilanafos	Japan	non-crop
86 - 1985	Herbicide	dimepiperate	Japan	Rice
87 - 1985	Herbicide	pyrazoxyfen	Japan	Rice
88 - 1986	Fungicide	pyroquilon	Japan	Rice
89 - 1986	Insecticide	etofenprox	Japan	Rice
90 - 1986	Insecticide	fenothiocarb	Japan	F&V
91 - 1986	Insecticide	bensultap	Japan	Rice
92 - 1987	Fungicide	tolclofos-methyl	Japan	F&V
93 - 1987	Fungicide	diclomezine	Japan	Rice
94 - 1987	Herbicide	esprocarb	Japan	Rice
95 - 1987	Insecticide	benfuracarb	Japan	Rice
96 - 1987	Insecticide	cycloprothrin	Japan	Rice
97 - 1987	Other	heptopargil	Japan	Rice
98 - 1987	Other	inabenfide	Japan	Rice
99 - 1988	Fungicide	tecloftalam	Japan	Rice
100 - 1988	Fungicide	oxolinic acid	Japan	Rice
101 - 1989	Fungicide	pefurazoate	Japan	F&V
102 - 1989	Insecticide	pyraclofos	Japan	F&V
103 - 1989	Other	triapenthenol	Japan	Rice
104 - 1980	Herbicide	fluazifop	NAFTA	soybean
105 - 1980	Herbicide	propyzamide	NAFTA	F&V
106 - 1981	Herbicide	fluridone	NAFTA	non-crop
107 - 1982	Herbicide	sulfometuron	NAFTA	non-crop
108 - 1984	Herbicide	fenoxaprop	NAFTA	Soybean
109 - 1984	Herbicide	lactofen	NAFTA	Soybean
110 - 1985	Herbicide	acetochlor	NAFTA	Maize
111 - 1985	Herbicide	thifensulfuron	NAFTA	Soybean
112 - 1985	Herbicide	imazapyr	NAFTA	Soybean
113 - 1985	Herbicide	chlorimuron	NAFTA	Soybean
114 - 1985	Other	amidochlor	NAFTA	many
115 - 1986	Herbicide	haloxyfop	NAFTA	Soybean
116 - 1986	Herbicide	imazaquin	NAFTA	Soybean
117 - 1986	Herbicide	clomazone	NAFTA	Soybean
118 - 1986	Insecticide	tralomethrin	NAFTA	many
119 - 1987	Herbicide	imazethapyr	NAFTA	Soybean
120 - 1987	Herbicide	clethodim	NAFTA	Soybean
121 - 1988	Insecticide	flucycloxuron	NAFTA	mites
122 - 1989	Insecticide	hexaflumuron	NAFTA	F&V
123 - 1988	Insecticide	tefluthrin	USA	Maize

Appendix 2

Focus of products introduced between 1990 and 1999

No. Year	Sector	Active Indredient	Region	Crop
1 - 1990	Herbicide	propaquizafop	Europe	BL Crops
2 - 1991	Herbicide	quinmerac	Europe	BL Crops
3 - 1990	Herbicide	amidosulfuron	Europe	Cereals
4 - 1992	Fungicide	bromuconazole	Europe	Cereals
5 - 1997	Herbicide	carfentrazone	Europe	Cereals
6 - 1999	Herbicide	cinidon-ethyl	Europe	Cereals
7 - 1991	Herbicide	clodinafop	Europe	Cereals
8 - 1994	Fungicide	cyprodinil	Europe	Cereals
9 - 1992	Fungicide	dimethomorph	Europe	Cereals
10 - 1993	Fungicide	epoxiconazole	Europe	Cereals
11 - 1992	Herbicide	ethoxyfen	Europe	Cereals
12 - 1991	Fungicide	fenbuconazole	Europe	Cereals
13 - 1994	Fungicide	fludioxonil	Europe	Cereals
14 - 1998	Herbicide	flufenacet	Europe	Cereals
15 - 1997	Herbicide	flupyrsulfuron	Europe	Cereals
16 - 1994	Fungicide	fluquinconazole	Europe	Cereals
17 - 1997	Herbicide	flurtamone	Europe	Cereals
18 - 1996	Fungicide	kresoxim-methyl	Europe	Cereals
19 - 1993	Fungicide	metconazole	Europe	Cereals
20 - 1994	Herbicide	metosulam	Europe	Cereals
21 - 1994	Others	prohexadione	Europe	Cereals
22 - 1997	Fungicide	quinoxyfen	Europe	Cereals
23 - 1997	Fungicide	spiroxamine	Europe	Cereals
24 - 1991	Fungicide	tetraconazole	Europe	Cereals
25 - 1992	Others	trinexapac-ethyl	Europe	Cereals
26 - 1992	Fungicide	triticonazole	Europe	Cereals
27 - 1991	Insecticide	acrinathrin	Europe	F&V
28 - 1997	Insecticide	diflovidazin	Europe	F&V
29 - 1998	Fungicide	famoxadone	Europe	F&V
30 - 1992	Insecticide	fenazaquin	Europe	F&V
31 - 1999	Insecticide	novaluron	Europe	F&V
32 - 1991	Herbicide	rimsulfuron	Europe	Maize
33 - 1990	Herbicide	sulcotrione	Europe	Maize
34 - 1994	Insecticide	pymetrozine	Europe	Potato
35 - 1992	Herbicide	triflusulfuron	Europe	Sugarbeet
36 - 1990	Fungicide	diethofencarb	Europe	Vine
37 - 1999	Fungicide	ethaboxam	Europe	Vine
38 - 1999	Fungicide	fenhexamid	Europe	Vine
39 - 1995	Fungicide	mepanipyrim	Europe	Vine
40 - 1993	Fungicide	pyrimethanil	Europe	Vine
41 - 1996	Herbicide	quizalofop-p-tefuryl	Americas	BL Crops
42 - 1992	Herbicide	flupoxam	Americas	Cereals
43 - 1999	Others	cyclanilide	Americas	Cotton
44 - 1995	Insecticide	diafenthiuron	Americas	Cotton
45 - 1998	Others	fluthiacet	Americas	cotton
46 - 1996	Herbicide	pyrithiobac	Americas	Cotton
47 - 1991	Fungicide	acibenzolar	Americas	F&V
48 - 1998	Others	aminoethoxyvinyl glycine	Americas	F&V
49 - 1999	Insecticide	bifenazate	Americas	F&V
50 - 1993	Insecticide	methoxyfenozide	Americas	F&V
51 - 1992	Insecticide	tebufenozide	Americas	F&V
52 - 1994	Herbicide	thiazopyr	Americas	F&V
53 - 1993	Insecticide	chlorethoxyfos	Americas	Maize
54 - 1993	Herbicide	diflufenzopyr	Americas	Maize
55 - 1999	Herbicide	dimethenamid	Americas	Maize
56 - 1997	Herbicide	isoxaflutole	Americas	Maize
57 - 1997	Herbicide	nicosulfuron	Americas	Maize
58 - 1996	Herbicide	prosulfuron	Americas	Maize
59 - 1996	Insecticide	tebupirimfos	Americas	Maize
60 - 1999	Herbicide	cloransulam-methyl	Americas	Soybean
61 - 1991	Herbicide	diclosulam	Americas	Soybean
62 - 1996	Herbicide	flumetsulam	Americas	Soybean
63 - 1996	Herbicide	flumiclorac-pentyl	Americas	Soybean
64 - 1995	Herbicide	flumioxazin	Americas	Soybean
65 - 1991	Herbicide	imazamox	Americas	Soybean
66 - 1996	Herbicide	oxasulfuron	Americas	Soybean
67 - 1993	Herbicide	sulfentrazone	Americas	Soybean
68 - 1994	Herbicide	imazapic	Americas	Sugarcane
69 - 1997	Insecticide	halofenozide	Americas	Turf
70 - 1999	Insecticide	indoxacarb	Asia	Cotton
71 - 1998	Insecticide	etoxazole	Asia	F&V
72 - 1991	Insecticide	fenpyroximate	Asia	F&V
73 - 1998	Insecticide	flubrocythrinate	Asia	F&V
74 - 1992	Fungicide	flusulfamide	Asia	F&V
75 - 1993	Insecticide	halfenprox	Asia	F&V
76 - 1994	Fungicide	imibenconazole	Asia	F&V
77 - 1991	Insecticide	milbemectin	Asia	F&V
78 - 1995	Insecticide	nitenpyram	Asia	F&V
79 - 1999	Herbicide	pyraflufen-ethyl	Asia	F&V
80 - 1992	Insecticide	tebufenpyrad	Asia	F&V
81 - 1999	Insecticide	acequinocyl	Asia	F&V
82 - 1996	Insecticide	chlorfenapyr	Asia	Many
83 - 1995	Insecticide	pyrimidifen	Asia	Many
84 - 1995	Insecticide	pyriproxyfen	Asia	Many
85 - 1997	Herbicide	azimsulfuron	Asia	Rice
86 - 1990	Herbicide	benzofenap	Asia	Rice
87 - 1997	Herbicide	bispyribac-sodium	Asia	Rice
88 - 1997	Herbicide	cafenstrole	Asia	Rice
89 - 1997	Fungicide	carpropamid	Asia	Rice
90 - 1990	Herbicide	cinosulfuron	Asia	Rice
91 - 1995	Herbicide	cumyluron	Asia	Rice
92 - 1997	Herbicide	ethoxysulfuron	Asia	Rice
93 - 1994	Herbicide	etobenzanid	Asia	Rice
94 - 1992	Fungicide	ferimzone	Asia	Rice
95 - 1997	Fungicide	furametpyr	Asia	Rice
96 - 1994	Herbicide	halosulfuron	Asia	Rice
97 - 1993	Herbicide	imazosulfuron	Asia	Rice
98 - 1994	Fungicide	ipconazole	Asia	Rice
99 - 1996	Herbicide	oxadiargyl	Asia	Rice
100 - 1998	Herbicide	pentoxazone	Asia	Rice
101 - 1999	Herbicide	profoxydim	Asia	Rice
102 - 1990	Herbicide	pyrazosulfuron	Asia	Rice
103 - 1996	Herbicide	pyribenzoxim	Asia	Rice
104 - 1990	Herbicide	pyributicarb	Asia	Rice
105 - 1996	Herbicide	pyriminobac-methyl	Asia	Rice
106 - 1992	Insecticide	silafluofen	Asia	Rice
107 - 1994	Herbicide	thenylchlor	Asia	Rice
108 - 1997	Fungicide	thifluzamide	Asia	Rice
109 - 1997	Herbicide	cyclosulfamuron	Asia	Rice
110 - 1996	Herbicide	cyhalofop-butyl	Asia	Rice
111 - 1997	Herbicide	sulfosulfuron	Global	Cereals
112 - 1999	Fungicide	iprovalicarb	Global	F&V
113 - 1995	Insecticide	spinosad	Global	F&V
114 - 1998	Insecticide	emamectin benzoate	Global	F&V
115 - 1993	Insecticide	alanycarb	Japan	F&V
116 - 1996	Insecticide	acetamiprid	Global	Many
117 - 1997	Fungicide	azoxystrobin	Global	Many
118 - 1993	Insecticide	fipronil	Global	Many
119 - 1991	Insecticide	imidacloprid	Global	Many
120 - 1993	Insecticide	lufenuron	Global	Many
121 - 1990	Insecticide	pyridaben	Global	Many
122 - 1999	Insecticide	thiamethoxam	Global	Many
123 - 1992	Insecticide	zeta-cypermethrin	Global	Many
124 - 1991	Insecticide	fosthiazate	Global	Potato
125 - 1990	Herbicide	ethametsulfuron	NAFTA	Canola
126 - 1995	Herbicide	butroxydim	S. Hemis'	Sunflower
127 - 1990	Herbicide	dithiopyr	USA	Turf
128 - 1994	Insecticide	triazamate	USA	Cereals

Appendix 3

Focus of products introduced from 2005 and by 2014

No. Year	Sector	Active Indredient	Region	Crop
1 - 2005	Fungicide	proquinazid	Europe	Cereals
2 - 2006	Herbicide	topramezone	Europe	Maize
3 - 2006	Herbicide	pethoxamid	Europe	Maize
4 - 2007	Fungicide	meptyldinocap	Europe	F&V
5 - 2007	Herbicide	orthosulfamuron	Europe	Rice
6 - 2010	Fungicide	bixafen	Europe	Cereals
7 - 2010	Fungicide	valifenalate	Europe	F&V
8 - 2010	Fungicide	isopyrazam	Europe	Cereals
9 - 2011	Fungicide	sedaxane	Europe	Seed Treatment
10 - 2012	Fungicide	fluxapyroxad	Europe	Many
11 - 2012	Fungicide	fluopyram	Europe	Many
12 - 2012	Fungicide	penflufen	Europe	Seed Treatment
13 - 2011	Herbicide	indaziflam	Americas	Sugarcane, Turf
14 - 2005	Insecticide	amidoflumet	Asia	non crop
15 - 2005	Insecticide	dimefluthrin	Asia	non crop
16 - 2006	Fungicide	enestroburin	China	F&V
17 - 2006	Fungicide	Jun Si Qi	China	F&V
18 - 2008	Fungicide	fenamistrobin	China	Rice
19 - 2009	Fungicide	pyraoxystrobin	China	F&V
20 - 2005	Herbicide	penoxsulam	Global	Rice
21 - 2005	Insecticide	spiromesifen	Global	Mites
22 - 2005	Other	florchlorfenuron	Global	F&V
23 - 2006	Fungicide	fluopicolide	Global	F&V
24 - 2006	Herbicide	pinoxaden	Global	Cereals
25 - 2007	Fungicide	mandipropamid	Global	F&V
26 - 2007	Herbicide	tembotrione	Global	Maize
27 - 2007	Herbicide	pyroxsulam	Global	Cereals
28 - 2010	Fungicide	ametoctradin	Global	F&V
29 - 2010	Insecticide	dimethyl disulfide	Global	Fumigant
30 - 2012	Insecticide	sulfoxaflor	Global	Sucking pest
31 - 2012	Insecticide	cyantraniliprole	Global	F&V
32 - 2014	Insecticide	flupyradifurone	Global	F&V
33 - 2007	Insecticide	metaflumizone	Global	Lepidoptera
34 - 2007	Insecticide	flubendiamide	Global	Lepidoptera
35 - 2008	Insecticide	spirotetramat	Global	Sucking pests
36 - 2008	Insecticide	chlorantraniliprole	Global	Lepidoptera
37 - 2005	Herbicide	MTB-951	Japan	Rice
38 - 2006	Herbicide	triaziflam	Japan	Rice
39 - 2007	Fungicide	orysastrobin	Japan	Rice
40 - 2007	Insecticide	cyflumetofen	Japan	F&V
41 - 2008	Fungicide	amisulbrom	Japan	F&V
42 - 2009	Fungicide	penthiopyrad	Japan	Vegetables, Turf
43 - 2009	Herbicide	propyrisulfuron	Japan	Rice
44 - 2009	Herbicide	pyrimisulfan	Japan	Rice
45 - 2009	Herbicide	pyraclonil	Japan	Rice
46 - 2009	Insecticide	imicyafos	Japan	F&V
47 - 2009	Insecticide	cyenopyrafen	Japan	F&V
48 - 2010	Fungicide	isotianil	Japan	Rice
49 - 2010	Insecticide	lepimectin	Japan	F&V
50 - 2010	Insecticide	pyrifluquinazon	Japan	F&V
51 - 2011	Fungicide	pyriofenone	Japan	F&V
52 - 2012	Fungicide	pyribencarb	Japan	F&V
53 - 2012	Fungicide	fenpyrazamine	Japan	F&V
54 - 2012	Herbicide	metazosulfuron	Japan	Rice
55 - 2013	Fungicide	isofetamid	Japan	F&V
56 - 2013	Insecticide	flometoquin	Japan	F&V
57 - 2013	Insecticide	pyflubumide	Japan	Mites
58 - 2014	Insecticide	afidopyropen	Japan	Sucking pest
59 - 2005	Herbicide	flucetosulfuron	Korea	Rice
60 - 2005	Insecticide	bistrifluron	Korea	F&V
61 - 2008	Herbicide	metamifop	Korea	Rice
62 - 2005	Insecticide	ethiprole	NAFTA	F&V
63 - 2005	Insecticide	noviflumuron	NAFTA	Termites
64 - 2005	Insecticide	iodomethane	NAFTA	Fumigant
65 - 2006	Herbicide	aminopyralid	NAFTA	Range and Pasture
66 - 2007	Herbicide	pyrasulfotole	NAFTA	Cereals
67 - 2009	Herbicide	thiencarbazone	NAFTA	Maize, Cereals
68 - 2009	Herbicide	saflufenacil	NAFTA	Many
69 - 2011	Herbicide	aminocyclopyrachlor	NAFTA	Range and Pasture
70 - 2011	Herbicide	pyroxasulfone	NAFTA	Maize, Soybean
71 - 2007	Insecticide	spinetoram	USA	F&V
72 - 2008	Herbicide	tefuryltrione	USA	Rice, Cereals
73 - 2010	Insecticide	Bacillus firmis	USA	Maize, Cotton

Notes

R&D trends

for chemical crop protection products and the position of the European Market

September 2013