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| **2,4-D** | **Product Type:** | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | Phenoxyacetic acid | 585 | 1945 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | **Structure** | |
| Nufarm (2,4-D) | Dow, Atul, UPL, Adama, Nitrokemia, Agro-San, Ancom, Amvac, Atanor, Meghmani, CAC Group | |
| **Application** | **Timing:** Post-Emergence | **Rate – (g/ha):** 200-2000 |
| **Main Crops** | **Main Pests** | |
| Cereals, Non-crop, Maize, Soybean, Rice, Sugarcane | Broadleaved weeds | |
| **Main Mixture Partners :** MCPA,MCPP, cinidon ethyl, dicamba, florasulam, fluroxypyr, bromoxynil, triclopyr, pinoxaden, clodinafop | | | | |
| **Recent History:**  2,4-Dichlorophenoxyacetic acid (2,4-D) is a mature, commodity herbicide, although it remains an important product in low-cost broadleaf weed control strategies across a wide range of crops. There are a number of different formulations of 2,4-D for numerous end use products, primarily as a sole active ingredient but also in conjunction with mixture partners. It has achieved full re-registration in the EU, with an extension to the current approval granted to the end of 2015. Re-registration was gained in Canada in 2008. Nufarm holds a major market share which was further strengthened with the purchase of BASF’s phenoxy business in 2004 and the UK-based AH Marks in 2008. The company launched a new formulation and commissioned a new production facility for the product in India in 2012.  Dow is in the process of commercialisation of corn, soybeans and cotton tolerant to 2,4-D and glyphosate under the Enlist brand, and has further developed soybeans tolerant to 2,4-D, glyphosate and glufosinate under the Enlist E3 brand. The Enlist Duo herbicide component of this weed control system, which has received approval in the USA and Canada, contains glyphosate and Colex-D, based on the choline salt of 2-4,D. Enlist One (2,4-D choline) is scheduled for US launch on maize, soybean and cotton in 2018. The Enlist trait in corn and soybeans has been approved in Canada and the USA with commercial launch in corn expected in the USA in 2018, whilst Enlist E3 soybeans have received approval in the USA and Argentina. Enlist cotton was launched in the USA at the beginning of 2016. | | | | |

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| **2,4-DB** | **Product Type:** | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | Phenoxyacetic acid | <30 | 1945 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | **Structure** | |
| Nufarm (Embutox, Butyrac) | Cedar Chemicals, UPL, Atanor | |
| **Application** | Timing: Post-emergence | **Rate – (g/ha):** 200-1700 |
| **Main Crops** | **Main Pests** | |
| Non-crop, Rice, Cereals | Broadleaved weeds | |
| **Main Mixture Partners :** | | | | |
| **Recent History:**  2,4-D analogue which is of little commercial significance, with the main crop outlets being cereals and rice. Nufarm and Aceto acquired the US rights to the product from Adama in 2004. EU approval, submitted by Nufarm, was renewed for 15 years in 2017 for use on cereals and legumes. | | | | |

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| **Abamectin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural product | 430 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Vertimec, Avicta) | Chinese companies, Nortox, Sinon, Amvac | | |
| **Application** | Timing: | Foliar,  Seed treatment | Rate – (g/ha): 5-450 |
| **Main Crops** | **Main Pests** | | |
| F&V | Leaf miners and a range of insects and mites | | |
| Cotton, Soybean, Rice | Lepidoptera, thrips, mites, nematodes | | |
| Pome fruit, Vine, Cereals | A wide range of insects and mites | | |
| **Main Mixture Partners :** thiamethoxam, chlorantraniliprole | | | | | |
| **Recent History:**  Avermectin insecticide/acaricide derived from the fermentation of *Streptomyces avermitilis*, acquired by Novartis from Merck in 1997 and now a significant element in Syngenta’s insecticide portfolio. In 2007 Syngenta acquired the exclusive license for Merck’s manufacturing technology for the product. Abamectin achieves translaminar absorption and hence has activity against leaf eating insects and mites. The product also finds major use in the animal health sector. EU re-registration has been achieved. Generic competition is now widespread: Adama gained the first generic registration in the USA in 2004, with Rotam introducing two formulations in the same year. Rotam later launched Acarimik in 2009 and Abacus V in California in 2014. Adama launched a low volatile organic compound formulation in the US in 2012 as Abba Ultra. Amvac acquired avermectin from Adama in June 2017.  The seed treatment product Avicta was introduced in the USA by Syngenta in 2005 for nematode control in cotton, followed in 2009 for use on maize and in 2010 for soybean. Syngenta entered into an agreement with Dow’s Mycogen subsidiary in 2010 in which Mycogen will offer Avicta on SmartStax maize in the USA. Avicta was also launched in Argentina in 2010. Agri-Flex, a mixture with thiamethoxam, was approved in 2010 for use on citrus in the USA and Voliam Targo, a mixture with chlorantraniliprole, was launched in Italy and Turkey in 2012 and in Spain in 2017. In 2015 Syngenta Canada launched a new formulation of Agri-Mek SC for use in speciality and horticultural crops. The following year Agri-Mek SC was approved for use on soybean in the USA. | | | | | |

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| **Acephate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | 465 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Orthene, Ortran) | Sumitomo Chemical, Rallis, Meghmani, UPL, FMC, FarmHannong, Sinon, Sabero, Heranba, Amvac, Nortox, Punjab Chemicals, Hubei Sanonda | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 560-1100 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Plantation crops, Maize, Cereals | A wide range of insects / mites and nematodes | | |
| Cotton | Bollworm, other lepidoptera, whitefly, thrips, aphids | | |
| Rice | Brown planthopper, green leafhopper | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus that is consistently one of the largest selling insecticides on the global market. Amvac acquired the US rights to the product from Sumitomo Chemical’s Valent subsidiary in 2008, with Arysta having the rights in the rest of the world. Launched by Arysta in India in 2012.  EU registration has been refused, whilst usage has also been banned in New Zealand. Received extra use restrictions in Brazil, the leading country market for the product, in 2013 and further procedures were incorporated into the trade of acephate in 2017. Canada's PMRA proposed continued registration in 2016. UPL received extension of approval in Brazil for kidney beans and peanuts in 2017. | | | | | |

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| **Acequinocyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Kanemite) | Arysta LifeScience | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 150-1050 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Tea, Ornamentals | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Napthoquinone acaricide which is active against all stages of mite development. Introduced in Japan and Korea in 1999 and became one of the leading miticides in the region. Marketed by Arysta in the USA for non–crop uses and outdoor nursery ornamentals under the brand name Shuttle, and as Piton for food crop use (almonds, citrus and pome fruit). In 2006 Agro-Kanesho received approvals in Colombia for use on ornamentals and in Israel for use on apples and vegetables. Received EU approval in 2014, with certain risk mitigation measures, and has also been approved in many European country markets, including Germany, Switzerland, the Netherlands, France and Greece, as well as Argentina. Agro-Kanesho received further country approvals for the product in 2014 in Poland, Egypt and Jordan. | | | | | |

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| **Acetamiprid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 250 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Mospilan) | Rallis, Meghmani, Shandong Sino-Agri United, Hailir Pesticides & Chemicals, Arysta LifeScience | | |
| **Application** | Timing: | Foliar, soil applied, seed treatment | **Rate – (g/ha):** 20-100 |
| **Main Crops** | **Main Pests** | | |
| Cotton | Bollworm complex, Other Lepidoptera, Whitefly, Thrips, Aphids | | |
| F&V, Pome fruit, Rice, Soybean, Cereals, Rape | A wide range of insects | | |
| **Main Mixture Partners :** bifenthrin, alpha cypermethrin, pyriproxifen, fenpropathrin | | | | | |
| **Recent History:**  Introduced by Nippon Soda in 1996 as Mospilan for the control of a wide range of insects including aphids, thrips, diamondback moths and leafminers predominantly on fruit and vegetables. Can be used by soil, seed treatment or foliar application, and has ovicidal and larvicidal activity against Hemiptera, Coleoptera and Lepidoptera. The product has been introduced in over 50 countries, including in East Asia, Latin America, North America and the EU, where it achieved Annex 1 listing in 2005. The product is marketed by Certis in Belgium, France, Netherlands and the UK (as InSyst); Sipcam in Italy (as Epik), Spain and Portugal; Efthymiadis in Greece; BASF in Spain; UPL in the USA; and Engage Agro in Canada. Introduced by FMC as Terminator, a cockroach bait, in 2005. Gowan acquired the rights on cotton in the USA in 2010. In 2012 Gowan and Nisso America received approval for the product in the USA in a mixture with bifenthrin as Justice for use on soybean. In 2014 BASF launched Fastac Duo (acetamiprid and alpha-cypermethrin) in Argentina. During 2015 Certis gained 120-day emergency approval for InSyst in the UK for the control of cabbage stem flea beetles in oilseed rape. Exosect has developed a delivery method whereby the active ingredient can be used as a seed treatment through the use of the company’s patented Entostat technology. Ihara launched Privilege (with pyriproxifen) and registered Bold (with fenpropathrin) in Brazil in 2017. | | | | | |

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| **Acetochlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 420 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Harness) | Dow, Nitrokemia, Sagrochem, Adama, Nantong Jiangshan | | |
| **Application** | Timing: | Pre-plant incorporated, pre-emergence | **Rate – (g/ha):** 1750-2500 |
| **Main Crops** | **Main Pests** | | |
| Maize, Soybean, Sunflower, Rape, Sugarcane, Cotton | Grasses and broadleaved weeds | | |
| **Main Mixture Partners :** flurochloridone, atrazine, flumetsulam, clopyralid, mesotrione, fomesafen | | | | | |
| **Recent History:**  Although originally introduced in 1985, the launch of safened versions of the product in 1993 as Surpass (Zeneca) and Harness (Monsanto) resulted in significant commercial success. Market share was rapidly gained in the US maize sector, although this was tempered by the success of herbicide tolerant varieties and newer product introductions; however sales in this sector remain significant. Syngenta divested the Zeneca acetochlor business to Dow in 2000, with Dow introducing an advanced formulation in a mixture with atrazine (Keystone) in 2002. In 2004 Makhteshim (now Adama) gained generic registration in the USA for First Act and Double Team (a combination with atrazine). Launched by Gowan in 2006 as Imperium for use on corn. In 2007 Dow received US approval for SureStart (acetochlor, flumetsulam and clopyralid) for use over Roundup Ready maize. Monsanto launched the microencapsulated formulation Warrant for use on soybean and cotton in combination with glyphosate over Roundup Ready varieties in 2010. This product has since been added to the company’s Roundup Ready Plus program for use on soybeans and cotton. Monsanto received US EPA registration in 2015 for Warrant Ultra (acetochlor and fomesafen) and in 2016 for Warrant Plus for use on cotton and soybean, the company including the products in its Roundup Ready Plus program from 2016. Dow’s Resicore (acetochlor, mesotrione and clopyralid) corn herbicide gained approval from the US EPA during 2016. The a.i. is currently under registration review in the US with completion expected in 2020. | | | | | |

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| **Acibenzolar** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Other azole | <30 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Bion, Actigard) | None | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 10-50 |
| **Main Crops** | **Main Pests** | | |
| F&V, Tobacco, Cotton | A wide range of diseases | | |
| **Main Mixture Partners :** chlorothalonil, azoxystrobin | | | | | |
| **Recent History:**  Acibenzolar stimulates the natural defence mechanisms of plants against disease, with activity claimed on a wide range of crops. Launched in the USA in 2001. The product received approval in 2011 in Canada for use on tomatoes and tobacco. Has also been introduced in the USA for use on turf, with chlorothalonil as Daconil Action and with azoxystrobin as Heritage Action. Annex 1 inclusion has been achieved in the EU, but the product has yet to make any significant commercial impact in that market. Formal renewal of the EU approval was confirmed in 2016. | | | | | |

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| **Acifluorfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | <30 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Blazer, Storm) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 200-300 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Peanuts | Broadleaved weeds | | |
| **Main Mixture Partners :** bentazone | | | | | |
| **Recent History:**  Ageing herbicide now in a phase of sales decline, particularly in the soybean sector where it has been superseded by newer products and affected by the uptake of herbicide tolerant varieties. The most significant market is now for use on soybeans in Russia. The product finds additional sales on peanuts and fruit. The a.i. lost its registration in the EU and was divested by BASF to UPL in 2003. | | | | | |

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| **Aclonifen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | 60 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Bandur, Challenge) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 2400-3000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Potato, Sunflower | Grasses and broadleaved weeds | | |
| **Main Mixture Partners :** isoxaflutole, flurtamone, oxadiargyl, linuron | | | | | |
| **Recent History:**  Broad-spectrum pre-emergence herbicide that is utilised in a wide range of crop situations. Annex 1 approval has been granted in the EU. Launched in a mixture with oxadiargyl in Spain in 2009 as Opalo for broad spectrum weed control on tobacco and certain fruits and vegetables. The most significant country markets for the product are France, Germany and Italy. In 2017, the EU approval expiry date was confirmed as 31st July 2022. | | | | | |

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| **Acrinathrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <30 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Rufast) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-600 |
| **Main Crops** | **Main Pests** | | |
| Vine | Leaf hoppers, Mites | | |
| F&V | A wide range of insects / mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyrethroid with miticidal activity, the first to be based on nor-pyrethrique esters. Particular activity against mites and thrips led to acceptance in the vine and fruit sectors. A niche product, although re-registration was achieved in the EU in 2011. Cheminova (now part of FMC) now holds a worldwide licence for acrinathrin and has a global long-term supply agreement with Bayer**.** Outside Europe, the main market is Japan. In 2009 SDS Biotech launched the product as Azami Buster WP for use on fruit and vegetables in Japan. | | | | | |

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| **Alachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | <30 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Lasso) | Adama, Sinon, Nitrokemia, Sagrochem, IpiCi, Dow, Nortox, FarmHannong, Sinochem | | |
| **Application** | Timing: | Pre-plant incorporated,  Pre-emergence | **Rate – (g/ha):** 1100-6600 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Maize, Sunflower | Grasses | | |
| **Main Mixture Partners :** terbuthylazine, atrazine, linuron | | | | | |
| **Recent History:**  At one time a major herbicide for pre-emergence grass weed control on soybean and maize. Significant market share has now been lost to new introductions and the impact of herbicide tolerant crops, whilst applications have been restricted due to concerns of the potential contamination of groundwater. In 2008 Sinochem acquired the Asian rights to the product from Monsanto covering the businesses and assets in the Philippines, Thailand, Vietnam, Taiwan, India, Pakistan and Bangladesh. Sales in the USA have generally been in decline. The product has not been accepted for EU re-registration, and was banned in Peru in 2011. Nissan Chemical gained approval for the product in a mixture with linuron in the Japanese market for soybeans, potatoes and maize, whilst Shandong Zhongshi Chemical has achieved registration for the product in China. Currently under registration review in the USA. India has announced that it will completely ban import, manufacture and formulation by 2020. | | | | | |

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| **Alanycarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <10 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Orion, Onic) | None | | |
| **Application** | Timing: | Seed treatment,  Soil, Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum carbamate insecticide whose major market is for caterpillar control in orchards. Alanycarb is also active in the control of cotton bollworm but has yet to make a commercial impact in this sector. Has not been registered in the EU. | | | | | |

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| **Aldicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 55 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Temik) | Dow, Chinese companies | | |
| **Application** | Timing: | Soil application | **Rate – (g/ha):** 1000-33000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Soybean | A wide range of insects, mites and nematodes | | |
| Potato | Colorado beetles, Aphids, Leaf hoppers, Nematodes, | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum soil-applied insecticide and nematicide, with a broad range of crop applications. Regulatory concerns have impacted sales performance in recent years, with the product having been refused Annex 1 re-registration in the EU and being banned in Brazil in 2012. In 2010 Bayer cancelled US registrations on potatoes and citrus and phased it out of all world markets by 2014. In 2011 Ag Logic was granted US EPA approval for the Temik replacement product Meymik, with introduction in 2013. In China, registrations will end in 2018 with use to be phased out by 2020. | | | | | |

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| **Allyl-isothiocyanate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | **<30** | 2014 |
| Key Manufacturer / Brand: | Other Manufacturers: | | | Structure | |
| **Isagro (Dominus)** |  | | |
| **Application** | Timing: | Pre-plant | **Rate – (kg/ha):** 92-367 |
| **Crops** | **Main Pests** | | |
| F&V, vine fruit, turf | Fusarium, nutsedge, nematodes, other insects and weeds | | |
| **Recent History:**  Allyl isothiocyanate fumigant targeted at the US and Mediterranean markets. Initial US approvals in some states were gained in 2013, with the product now registered in over half of US states. Registration is currently pending in Massachusetts and Maine, whilst an application has been submitted in California with registration in that state expected in early 2018. | | | | | |

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| **Alpha-cypermethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 165 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Fastac) | FMC, Gharda, Bilag, Tagros, Coromandel, Meghmani, UPL, Bharat Rasayan, Heranba, Atabay | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 5-30 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Cereals, F&V, Rape, Maize | A wide range of insects. | | |
| **Main Mixture Partners :** acetamiprid, flufenozuron, teflubenzuron, imidacloprid | | | | | |
| **Recent History:**  Partially resolved pyrethroid with several crop, animal, and public health applications. Originally introduced by Shell before being acquired by Cyanamid as part of that business in 1994, and subsequently by BASF in 2000. Now a commodity product but still one of the leaders in the pyrethroid sector. Gained EU approval in 2015 for non-crop uses.  In 2013 BASF received the first US approval for the product for use on a range of crops including soybeans and cotton. In 2014 the company launched Fastac Duo (also containing acetamiprid) in Brazil for use on soybeans and Tacazo (also containing flufenoxuron) in Argentina. The product is also an important product for vector control, being incorporated into bednets and used as a space spray. In 2014 BASF received registration in Germany for its Storanet timber storage protection nets. In 2016 US approval was granted for Fastac CS, a microencapsulated formulation, on over 150 crops. Additionally, Canada proposed continued registration in 2016. | | | | | |

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| **Aluminium phosphide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 35 | 1958 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** AlP | |
| UPL | Sanonda, Excel Crop Care | | |
| **Application** | Timing: | Post-harvest | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Stored grains | Insects and rodents | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Main usage is in the post-harvest market and fumigation of facilities. The product reacts with water to release phosphine. In 2011 China restricted applications for field testing, registration and manufacture of the product, with these measures designed to lead to an eventual ban in the country. The product has been re-registered in the EU. An EU approval expiry date has been set at 2022. | | | | | |

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| **Ametoctradin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Triazolopyrimidine | <30 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Initium) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Potato, Vine, F&V | Late blight, downy mildew | | |
| **Main Mixture Partners :** dimethomorph, mancozeb, metiram | | | | | |
| **Recent History:**  Triazolopyrimidine fungicide for the control of late blight and downy mildew on a range of crops including potato, vine and fruit & vegetables. Features a novel mode of action, inhibiting fungal activity by binding to the stigmatellin subsite in the respiratory complex III of the fungus.  Developed for use in a mixture with dimethomorph as Zampro for use on crops and Orvego for ornamentals. The first approval for the product was in Romania in 2010 for use on vines as Enervin and on fruit and vegetables as Zampro. Zampro has received further approvals in several country markets, including the USA, Australia, Canada, Chile and Ecuador. The product was approved in Italy in 2012 with dimethomorph as Enervin Duo, and with metiram as Enervin Top. Received European Annex 1 approval in 2013 and approved in Canada, Japan and China in 2014. Launched in 2015 in Spain, and in France as Resplend (ametoctradin and dimethomorph) for the control of mildew in vine. | | | | | |

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| **Ametryn** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 75 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Gesapax) | Adama, Oxon, Atanor, Meghmani, Shandong Weifang | | |
| **Application** | Timing: | Pre-emergence, post-emergence | **Rate – (g/ha):** 1000-7000 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, F&V, Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** clomazone, 2,4-D, atrazine | | | | | |
| **Recent History:**  Early broad-spectrum triazine herbicide used mainly in niche markets for the control of broadleaved and grass weeds, particularly in orchards, sugarcane, soft fruits and citrus. Now of limited commercial significance, but maintains sales due to a relatively low cost and broad spectrum of action. Not supported through re-registration in the EU. In 2004 Syngenta removed the usage on bananas and non-crop areas in the USA. In 2010 Shandong Weifang Rainbow Chemical received approval for the manufacture of the product in China. Syngenta divested various products in its Mexican ametryn business to Amvac Mexico in 2017. | | | | | |

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| **Amicarbazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 70 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Dinamic, Pegaso) | None | | |
| **Application** | Timing: | Pre-plant Incorporation (maize), Pre- and Post-emergence (sugarcane) | **Rate – (g/ha):** 500-1200 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane | Broadleaved weeds, grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Applied to ratoon stubble post-harvest to provide residual weed control. Arysta LifeScience acquired the rights from Bayer in 2002. Registered in the USA and Brazil in 2004, with Brazil by far the most significant country market for the product. Introduced in Australia and the Philippines in 2006, with approvals for use on sugarcane achieved in South Africa in 2011 and Thailand in 2012. Arysta gained US approvals in 2012 as Xonerate and Dinamic for use on turf. Arysta’s acquisition of Devidayal Sales in 2012 has led to accelerated registration and development opportunities for the product in India. In 2014 Arysta received registration for Dinamic in China for use on maize. | | | | | |

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| **Amidoflumet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide (sulfonanilide) | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Panduck) |  | | |
| **Application** | Timing: |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop | House dust mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Acaricide developed for the control of house dust mites. Introduced in Japan in 2005. | | | | | |

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| **Amidosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Sulfonylurea | 30 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Gratil) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 15-30 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Linseed, Pasture | Broadleaved weeds | | |
| **Main Mixture Partners :** iodosulfuron, isoproturon | | | | | |
| **Recent History:**  A niche market herbicide for cleaver (*Gallium aparine*) control in cereals, effective against early stages of weed development. Sales have benefited from usage in mixture formulations in what has become a very competitive market, although recent results have been depressed by increasing competition from new introductions in the cleaver control sector. As cleavers are only a major problem in Europe, the geographical spread of the product is limited. EU re-registration has been achieved. Also approved for the control of docks on pasture land, the product being safe to white clover. Reportedly effective even at cold temperatures and for the control of volunteer oilseed rape. | | | | | |

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| **Aminocyclopyrachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <30 | 2011 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Plainview, Streamline, Viewpoint, Perspective) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 35-280 |
| **Crops** | **Main Pests** | | |
| Pasture, Turf, Industrial weed control | Broadleaf weeds, leafy spurge, mesquite, thistles and brush | | |
| **Recent History:**  A pyrimidine carboxylic acid herbicide, introduced in the USA in 2011 for non-crop use as Plainview for utility and industrial sites and as Streamline, Viewpoint and Perspective for roadside weed management. In 2011 DuPont halted the sale, distribution and use of the product as Imprelis for use on lawns and golf courses due to phytotoxicity issues with trees, however it remains on the market for the rangeland and pasture sector. | | | | | |

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| **Aminoethoxyvinyl glycine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <10 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Valent (ReTain) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit |  | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  An old product, but recently re-formulated and re-launched by Valent. Reduces fruit drop and improves overall fruit quality. Utilised in non-crop applications such as reducing post-harvest senescence of flower petals and fruiting bodies during transport. | | | | | |

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| **Aminopyralid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 160 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Tronador, Milestone) | None | | |
| **Application** | Timing: | Pre- and Post-emergence | **Rate – (g/ha):** 10-120 |
| **Main Crops** | **Main Pests** | | |
| Pasture, Rangeland, Oil palm, Rubber, F&V, Cereals | Broad spectrum particularly spotted knapweed and including Compositae, Fabaceae, and Polygonaceae families. | | |
| **Main Mixture Partners:** 2,4-D, fluroxypyr, glyphosate, triclopyr, metsulfuron-methyl, halauxifen | | | | | |
| **Recent History:**  An auxinic herbicide that is mobile in both the phloem and xylem and is rapidly absorbed by leaves and roots, used to control broadleaf weeds including many noxious and invasive weed species in natural areas, wildlands, rangeland, pastures, non-cropland, wheat, rape, oil palm, and rubber plantations. Aminopyralid is effective at very low rates when compared to many currently registered rangeland, pasture, and non-cropland herbicides with this mode of action.  Approvals were received in Canada and the USA, were it had been classified as a reduced risk pesticide, in 2005, followed by Argentina, Australia, Brazil, Colombia, Malaysia, Mexico, Panama, and the UK in 2006. Approved in Germany in 2007 in combination with fluroxypyr as Simplex. Launched in the UK in 2008 for grassland weed control as Banish. Approval in Canada was achieved in 2010 for ClearView, a mixture with metsulfuron-methyl for industrial and non-crop uses. Dow launched aminopyralid in a mixture with the new active ingredient halauxifen as ForageMax Arylex Active for use on forage brassicas in Australia in 2015. | | | | | |

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| **Aminotriazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <30 | 1953 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nufarm (Amitrol, Weedazol) | Adama | | |
| **Application** | Timing: | n.a. | **Rate – (g/ha):** 2200-8900 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, Vine | Non-selective | | |
| **Main Mixture Partners :** ammonium thiocyanate,diuron | | | | | |
| **Recent History:**  Commodity non-selective herbicide used in vineyards, orchards and non-crop situations. Has achieved EU re-registration. Formulations with diuron have been introduced in France by Sipcam to take advantage of market opportunities from other products failing to gain re-registration. Nufarm announced it would cease sales of Amitrol in Eastern Canada in 2016. Additionally, the European Commission instructed member states to withdraw approvals by September 2016. | | | | | |

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| **Amisulbrom** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Leimay, Shinkon, Oracle, Vortex) | None | | |
| **Application** | Timing: | Foliar, Soil, Seed | **Rate – (g/ha):** 60-120 |
| **Main Crops** | **Main Pests** | | |
| F&V, Potato | Downy mildew, late blight (oomycete diseases), club root, potato powdery scab | | |
| **Main Mixture Partners:** mancozeb | | | | | |
| **Recent History:** First global registration in the UK in 2007, marketed as Shinkon for use on potatoes. The primary target diseases are club root on brassica vegetables and powdery scab on potato. Also launched in South Korea and Japan in 2007, marketed as Myeonjak and Leimay. Achieved full EU approval in 2014. Nissan market the product in Japan, whilst appointed partner companies undertake marketing in overseas countries, including Philagro in France, Kenogard in Spain and ProCam in the UK. Approved in Germany as Shaktis WG in a mixture with mancozeb, and for use on vines in Italy. Soil applied formulations (as Oracle) were introduced in Japan in 2010, with seed treatment use on beans as Vortex. In 2016 Gowan became the UK distributor of Nissan’s Shinkon. In 2016, Nufarm gained approval in China and Australia for Amicus Blue (amisulbrom and tribasic copper sulphate) to control grapevine downy mildew, as well as white blister and downy mildew of brassicas. | | | | | |

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| **Amitraz** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Mitac) | Adama, Chinese companies | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 350-1000 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, Pome fruit, Cotton, F&V | Mites | | |
| **Main Mixture Partners :** metaflumizone | | | | | |
| **Recent History:**  Commodity broad-spectrum specific miticide with some insecticidal activity, particularly against whitefly. Amitraz also finds significant outlets in the animal health sector, particularly on cattle in Latin America. Refused re-registration in the EU and has now left that market. In 2004 Bayer voluntary cancelled the registrations in the US of Mitac and Ovasyn, the last registrations in the country for use on cotton and pears, and in 2005 divested the product to Arysta. A mixture with metaflumizone for the control of ticks and fleas in dogs, marketed by Fort Dodge as ProMeris, achieved US EPA registration in 2007. In 2016 Canada's PMRA renewed its conditional registration for Veto-Pharma's acaricide, Avipar Strips for control of varroa mites on honey bees. | | | | | |

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| **Anilazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1958 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Dyrene) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 1000-3000 |
| **Main Crops** | **Main Pests** | | |
| Non-Crop, Plantation crops | Broad range of diseases | | |
| **Main Mixture Partners :** chlorothalonil, benomyl | | | | | |
| **Recent History:**  Ageing triazine fungicide now predominantly used in mixtures, particularly with chlorothalonil and benomyl, but not supported through re-registration in the EU and left the market from July 2003. | | | | | |

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| **Anilofos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <30 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Arrozin) | Gharda | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 300-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** 2,4-D, propanil | | | | | |
| **Recent History:**  Organophosphorus herbicide of minor commercial significance for the control of annual grass weeds, including *Echinochloa crus-galli* (barnyard grass) in rice. The product is now subject to competition from local manufacture. Initially introduced in India, followed by marketing in combination with other products in Japan from 2001. The main country market is now China. | | | | | |

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| **Asulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <30 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Asulam, Asulox) | Dow, Aceto | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 1000-10000 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Plantation crops, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diuron, paraquat | | | | | |
| **Recent History:**  Carbamate herbicide acquired by UPL from Bayer in 2005. The product finds its main outlets in grass control in sugarcane, plantation crops and citrus. Sales are also achieved from usage in permanent pasture and plantation crops. The product is now mature although sales performance has been steady. Introduced by Aceto in the USA in 2007 for use on sugarcane. Has not been re-registered in the EU. | | | | | |

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| **Atrazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 560 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Primoleo, Proof, Gesaprim) | Adama, DuPont, Dow, Prochim, Nitrokemia, Budapest Chemical Works, Rallis, Herbos, Oxon, IpiCi, Meghmani, Nortox, Atanor, UPL, Nufarm | | |
| **Application** | Timing: | Pre-plant incorporated, pre-emergence, post-emergence | **Rate – (g/ha):** 450-4500 |
| **Main Crops** | **Main Pests** | | |
| Maize, Sugarcane, Cereals, Rape | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** acetochlor, alachlor, dicamba, fluthiacet-methyl, isoxaflutole, mesotrione, metolachlor, propisochlor, pyroxasulfone, simazine, s-metolachlor, bicyclopyrone | | | | | |
| **Recent History:**  The leading triazine herbicide with a wide range of applications and produced by many companies. Sales had been in decline due to regulatory action (groundwater), resistance development, and new competitive products, but in the main markets of Latin America and the USA, atrazine remains an effective, low-cost, broad-spectrum herbicide playing an important role in the maize and sugarcane sectors. Sales have benefited from usage in the USA on maize in a number of mixture formulations, notably Lexar and Lumax from Syngenta and Anthem ATZ with pyroxasulfone and fluthiacet-methyl, introduced in 2013 by FMC. These mixtures find usage on Roundup Ready corn through pre-emergence application for broad spectrum, persistent weed control allowing later season application of glyphosate. In 2014 Syngenta introduced Lumax EZ, also containing s-metolachlor and mesotrione, in Canada for use on maize. In 2015 Syngenta gained US and Canadian approval for the maize herbicide Acuron, containing atrazine, mesotrione, s-metolachlor and bicyclopyrone. The USDA reported that atrazine was applied to 60% of US maize in 2016. Syngenta divested various products in its Mexican atrazine business to Amvac Mexico in 2017. Nufarm launched Gesaprim 500 in Brazil in 2017 for use on maize, sorghum and sugarcane. | | | | | |

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| **Azimsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (to FMC) (Gulliver) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 20-25 |
| **Main Crops** | **Main Pests** | | |
| Rice, Sugarcane | Grasses and Broadleaved weeds | | |
| **Main Mixture Partners :** molinate, cafenstrole, pyrazoxyfen, benzobicyclon | | | | | |
| **Recent History:**  Herbicide for post-emergence control of barnyard grass, sedges and broadleaved weeds in rice. The product has achieved registration in the EU and was initially targeted at southern European markets, although introductions in Japan, South Korea, other Asian markets, Latin America and Australia have also been taken place. In 2011 Ishihara gained registration in Japan for Broad-cut, a mixture with cafenstrole, pyrazoxyfen and benzobicyclon. FMC agreed to acquire azimsulfuron from DuPont in April 2017 as part of the Dow-DuPont merger agreement. | | | | | |

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| **Azinphos-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | <30 | 1955 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Gusathion) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-2200 |
| **Main Crops** | **Main Pests** | | |
| Potato | Colorado beetles, Leaf hoppers | | |
| Plantation crops, F&V | A wide range of insects and mites. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum insecticide with a wide range of applications against sucking and biting pests, especially lepidopteran larvae. Several crop uses were cancelled in the USA in 2002, with usage on cotton ending in 2005. The product was phased out in Canada in 2006. In 2011 Australian authorities confirmed the proposed cancellation of the use of the product on citrus and kiwi fruit. Re-registration in the EU has been refused. Acquired by Makhteshim Agan (now Adama) from Bayer in 2007, with the company having previously gained the rights in Europe. The related azinphos-ethyl has already been phased out in most markets. In 2016 Argentina banned the manufacture, import and formulation of azinphos-methyl based products. Uruguay cancelled commercial registrations in 2017. | | | | | |

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| **Azocyclotin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Peropal) | FarmHannong | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 150-500 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, Pome fruit, F&V, Cotton | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Long-acting contact acaricide with activity against all motile stages of mites, acquired by Arysta from Bayer in 2005. Now superseded by newer products and has not received re-registration in the EU. | | | | | |

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| **Azoxystrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 1,270 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Amistar) | FMC, Chinese companies | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 100-1800 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Asian Rust, Brown spot, Aerial blight, Leaf blight, Frogeye leaf spot, pod and stem blight, Leaf and Stem spot, Target spot. | | |
| Cereals | Brown rust, yellow rust, Septoria leaf spot, Powdery mildew, Eyespot | | |
| Rice | Rice blast, Sheath blight, Bakanae disease | | |
| Vine | Downy mildew, Powdery mildew, Excoriosis | | |
| Potato | Potato blight, Black dot | | |
| Maize, F&V, Rape, Cotton | A wide range of diseases | | |
| **Main Mixture Partners :** cyproconazole, fenpropimorph, folpet, cymoxanil, propiconazole, fludioxonil, chlorothalonil, metalaxyl-M, tebuconazole | | | | | |
| **Recent History:**  Broad-spectrum strobilurin fungicide that is now the leading fungicide globally. The major crop markets for the product are soybeans, fruit & vegetables, cereals, rice, maize and potato. Annex 1 registered in the EU, but now under increasing pressure from other strobilurins and resistance by *Septoria* on cereals. Derives significant sales in the seed treatment sector where it is sold in many mixture formulations, and in the turf sector where it is sold as Heritage. Syngenta has supply agreements with Adama, Rallis and Nufarm. Now suffering patent expiry and generic competition with Cheminova (now part of FMC) launching Authority (a mixture with flutriafol) in Brazil in 2012, and Azaka and Equation in the USA and Europe in 2014. Syngenta and Arysta LifeScience co-market the product in India as Kinsta. In 2013 Syngenta launched Reflect Xtra, which also contains isopyrazam, for use on wheat in Argentina. A combination with benzovindiflupyr, Elatus, was approved in Brazil for use on soybeans in 2014. In 2015 Syngenta launched Heritage Action (azoxystrobin and acibenzolar) for turf in the USA whilst Adama introduced Topnotch (azoxystrobin and propiconazole) in Canada for use on cereals. During 2016 Syngenta received approvals in the US for Mural (also containing benzovindiflupyr), for Contend co-pack in turf and in Canada for Trivapro (azoxystrobin, propiconazole and benzovindiflupyr). FMC launched Topguard EQ (flutriafol and azoxystrobin) on over 20 crops in US in 2016. Adama was granted extensions to 20 crops for Azimut in Brazil in 2017. | | | | | |

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| ***Bacillus firmus*** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticides | | Natural Product | 60 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Poncho, Votivo) |  | | |
| **Application** | Timing: | Seed treatment, Drip/Drench | **Rate – (g/ha):** 5-25 |
| **Crops** | **Main Pests** | | |
| Maize, Cotton, Soybean | Nematodes | | |
| **Main Mixture Partners:** clothianidin | | | | | |
| **Recent History:**  Biological nematicide/nematode suppressant that is mainly used as a seed treatment alongside the insecticide Poncho (clothianidin) as Poncho / Votivo, first introduced in the USA for use on maize in 2011, followed by cotton and soybeans in 2012. In 2016 the product was also approved for use in New Zealand. Monsanto has an agreement with Bayer for the supply of the product in Monsanto’s Acceleron seed treatment range. In 2014 Bayer launched Flocter in Italy for nematode control on a range of fruit and vegetables. New Zealand's EPA approved the import of Poncho/Votivo in 2016 for use in maize, sweet corn, cereals, forage brassicas and grass. Oleaje was approved as a seed treatment in 2017 in Brazil for use in cotton, maize and soybean. Bayer plans to launch a second generation version of Poncho/Votivo (clothianidin and *Bacillus firmus* strain I-1582), in the US for the 2019 planting season. | | | | | |

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| ***Bacillus subtilis*** | **Product Type:** | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | Natural Product | 55 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | **Structure** | |
| Bayer (Sonata, Serenade) |  | |
| **Application** | Timing: Seed treatment, soil, foliar | **Rate – (g/ha):** 1000-3400 |
| **Crops** | **Main Pests** | |
| F&V, Maize, Soybean | Wide range of common fungal and bacterial diseases | |
| **Main Mixture Partners:** pyraclostrobin | | | | |
| **Recent History:**  Developed by the US biopesticide company AgraQuest and passed on to Bayer following its acquisition of the company in 2012. Initially registered in the USA in 2000. Serenade, containing the *Bacillus subtilis* strain QST 713, has received registration in over twenty countries, as well as gaining Annex 1 listing in the EU. The product is intended for use in conjunction with chemical pesticides to provide control of a range of common fungal and bacterial diseases on a range of crops, including oilseed rape, fruit & vegetables and vines, with Bayer expected to extend this to maize and soybeans as a seed treatment as well as soil and foliar products in the future.  Introduced in Brazil, Chile, Costa Rica, Guatemala and Peru for use on fruit & vegetables in 2013. Serenade Max, a more concentrated version, was introduced in Italy in 2013 for use on vines. Serenade Optimum, a more concentrated version of Serenade Max, was launched in the USA in 2013 for use on fruit, vegetables, vines and nuts. In 2015 Bayer introduced Xanthion, a mixture of pyraclostrobin and *Bacillus subtilis*, in the USA. In 2017 Isagro USA was granted exclusive distribution rights of Taegro 2 (*Bacillus subtilis*). | | | | |

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| ***Bacillus thuringiensis*** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural product | 170 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Dipel) | Mitsui & Co (Certis) | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice, Soybean, Cotton, Maize | A wide range of insects. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  An insecticidal protein produced by the fermentation of various strains of the bacterium *Bacillus thuringiensis*, the most common being *kurstaki* and *israeliensis*. The market for *B.t*. products is driven by insect pressure in the forestry and fruit and vegetable sectors with minor usage on soybean, cotton and rice. The market for crops genetically manipulated to express *B.t.* insecticidal proteins is far more significant, with many of the sprayed *B.t.* businesses having been divested: Thermo Trilogy acquired the Novartis business (and was then acquired by Mitsui & Co in 2001) and Sumitomo Chemical acquired Abbott, the former leader in this field. Ecogen acquired the Mycogen product line, but then divested most of its *B.t.* business to the Mitsui & Co subsidiary Certis. Has achieved Annex 1 approval in the EU. In 2008 Certis Spain introduced Turex for control of lepidopteran larvae as a foliar spray or dust. Valent launched the mosquito control product VectoMax in the USA in 2009. In 2012 Summit Chemical licensed the rights to Amvac for Bti Briquets, a sustained release formulation of *Bacillus thuringiensis* subsp. *israelensis* for the mosquito larvicide market. In 2015 Valent BioSciences gained US registration for VectoPrime (*B.t. israelensis* and (S)-methoprene) larvicide for mosquito control. In the same year Valent gained approval in Canada for XenTari WG (*B.t. aizawai*) for use on F&V, oilseeds and ornamentals. In 2016 Phyllom BioProducts received in California under the grubGONE brand. In 2017 Sumitomo launched BioBit (*Bacillus thuringiensis*) in Italy, predominantly for vine and citrus crops. | | | | | |

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| **Beflubutamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Herbaflex) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 170-255 |
| **Main Crops** | **Main Pests** | | |
| Cereals (in mixtures with isoproturon) | Broadleaved weeds | | |
| **Main Mixture Partners :** isoproturon, ioxynil, mecoprop | | | | | |
| **Recent History:**  Amide herbicide originally developed by Ube Industries as UBH-820, a business that is now part of SDS Biotech. Stähler acquired the global development and marketing rights, as well as the EU approval data package for the product, from Ube in 2007, having previously held the European development rights. Introduced in Germany by Stähler in a mixture with isoproturon as Herbaflex, and by Agrodan in Spain. Arysta’s Czech and Slovakian subsidiaries distribute the product as Herbaflex and Trioflex (beflubutamid, ioxynil and mecoprop) in these countries. Achieved Annex 1 listing in the EU in 2007. Passed to FMC following its acquisition of Cheminova. | | | | | |

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| **Benalaxyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Phenylamide | <30 | 1982 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Galben) | Isagro (benalaxyl-m / kiralaxyl), Punjab Chemicals, Adama | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 1500-2000 |
| **Main Crops** | **Main Pests** | | |
| Vine | Downy mildew, Excoriosis | | |
| Potato | Early blight, Potato blight | | |
| F&V, Non-crop | A wide range of diseases | | |
| **Main Mixture Partners :** mancozeb, folpet | | | | | |
| **Recent History:**  A systemic fungicide for oomycete disease control originally developed by Isagro, competing directly with the larger selling metalaxyl, and also a number of recent entrants to the sector. The product has been licensed out for distribution throughout Europe, where it has received Annex 1 registration. Similar to all the phenylamides, it has suffered from resistance development. A single enantiomer version, benalaxyl-m (also known as kiralaxyl) gained its first registration in 2004 and was launched in Italy in 2007. EU Annex 1 registration of benalaxyl-m has also been achieved. Mixtures of benalaxyl-m with copper salts for Europe and chlorothalonil for American markets have also been developed. In 2009 FMC acquired all registrations, intellectual properties and trademarks for non-resolved benalaxyl from Isagro. In 2011 Adama gained a licence from Isagro to develop and sell seed treatments and formulations based on benalaxyl-m (as kiralaxyl). In 2017 Gowan crop Protection gained an exclusive licence from Isagro to produce benalaxyl-M based fungicides in Europe. | | | | | |

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| **Benazolin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Galtak, Cornox) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 225-700 |
| **Main Crops** | **Main Pests** | | |
| Rape | Broadleaved weeds | | |
| **Main Mixture Partners :** clopyralid, quizalofop-P-ethyl | | | | | |
| **Recent History:**  Minor rape herbicide used predominantly in mixtures for broadleaf weed control. Never a major product, benazolin is now of limited significance and is not registered in the EU or USA, with the main country market being China. | | | | | |

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| **Benfluralin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | <10 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Bonalan) | Adama, Budapest Chemical works, IpiCi | | |
| **Application** | Timing: | Pre-plant incorporated | **Rate – (g/ha):** 1000-1500 |
| **Main Crops** | **Main Pests** | | |
| Peanuts, Forage crops, F&V, Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Trifluralin analogue for use in niche markets for pre-emergence control of a broad spectrum of weeds, particularly in peanuts, lettuce and forage crops. Of minor commercial significance but fills a role in the dinitroaniline offering. Re-registered in the USA in 2004, although registration on peanuts was cancelled. EU re-registration has been achieved although only minor sales are gained in the region. In 2015 Gowan acquired Dow’s global dinitroaniline herbicide business. | | | | | |

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| **Benfuracarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | **<30** | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Oncol) | None | | |
| **Application** | Timing: | Foliar, Soil,  Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Brown plant hopper, Green leaf hopper, Leaf miner, Leaf beetle, Water weevil, | | |
| Plantation crops, F&V, Cotton | A wide range of insects/mites and nematodes. | | |
| **Main Mixture Partners :** probenazole, tiadinil, tricylazole | | | | | |
| **Recent History:**  Broad-spectrum carbamate insecticide whose major market is on rice in Japan. Sales are now well down from peak levels due to the reduction in the rice area in Japan and the impact of newer product introductions. Has also been introduced in a mixture with probenazole (Judge) for use in rice nursery boxes. The product is licensed out for marketing by a number of companies around the world. Has not been re-registered in the EU. | | | | | |

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| **Benfuresate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Longshot) | None | | |
| **Application** | Timing: | Pre-plant incorporated and Post-emergence | **Rate – (g/ha):** 450-3000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses and Broadleaved weeds | | |
| **Main Mixture Partners :** simetryn, MCPB, cyhalofop-butyl, fentrazamide, dimethametryn, pyrazolate | | | | | |
| **Recent History:**  Benzofurane herbicide with a broad spectrum of activity against grasses, broadleaved weeds and sedges. OAT Agrio acquired the product from Bayer in 2011. The major use is post emergence on rice; however the product also finds minor usage pre-plant incorporated in tobacco. Due to crop susceptibility, the product has only limited applications in the vegetable sector. Has not been re-registered in the EU. Used in a number of combination products in rice in Japan and South Korea. | | | | | |

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| **Benomyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Benzimidazole | <30 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sinon | Chinoin, FarmHannong | | |
| **Application** | Timing: | Foliar,  Seed treatment, Post-harvest | **Rate – (g/ha):** 140-1700 |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice, Cereals, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** thiram | | | | | |
| **Recent History:**  Broad-spectrum benzimidazole fungicide with a wide range of crop and disease applications. Metabolised to carbendazim by both plants and animals. DuPont withdrew from the manufacture and sale of the product in 2001. The product is no longer registered in the USA, the EU and Australia. The trade and use of benomyl is banned in India from 1st January 2018. | | | | | |

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| **Bensulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | 60 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Londax) | Chinese companies | | |
| **Application** | Timing: | Pre-emergence, post-emergence | **Rate – (g/ha):** 30-100 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** mefenacet, molinate, cumyluron, pentoxazone, daimuron, pyraclonil, bromobutide | | | | | |
| **Recent History:**  At one time bensulfuron was one of the largest selling sulfonylurea herbicides and the leading rice herbicide worldwide. The product is still the cornerstone of many of the leading ‘one-shot’ rice herbicides in Japan. Marketing covers most rice growing nations, although sales are in a phase of decline, exacerbated by the reduction in the Japanese rice area and increased competition from new introductions. Some competition from generic material from China is also encountered. The rights outside Asia were acquired by UPL from DuPont in 2006. Has achieved re-registration in the EU until November 2022.  Nihon Nohyaku launched the product in a mixture with daimuron, pyraclonil and bromobutide as Ippon D for use on paddy rice in the domestic market in 2010. Also introduced in Japan by Ishihara in 2011 as Dohji-Guard with cumyluron and pentoxazone. In 2014 Anhui Fengle received a Chinese patent for a water-dispersable granule formulation containing a mixture of bensulfuron and florasulam for use on wheat. | | | | | |

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| **Bensulide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | **<10** | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Prefar/Betasan) | PBI/Gordon | | |
| **Application** | Timing: | Pre-plant, pre-emergence | **Rate – (g/ha):** 5600-13900 |
| **Main Crops** | **Main Pests** | | |
| Lettuce, Brassicas, Vegetables, Turf | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Initially introduced by Stauffer, but now predominantly sold by Gowan for use on vegetable crops and by PBI/Gordon in non-crop markets. Also registered in Australia for use on turf. Has not been re-registered in the EU, leaving that market in 2003. | | | | | |

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| **Bensultap** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural product | <10 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Bancol) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 25-750 |
| **Main Crops** | **Main Pests** | | |
| Rice | Leaf beetle, Leaf rollers, Stem borer, | | |
| F&V | A wide range of insects. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Analogue of the natural toxin nereistoxin. Initially introduced for the control of a wide range of rice pests, bensultap also finds limited use in fruit & vegetables. The product is also active against pests of vine and brassicas, although sales in this crop sectors is limited. Has not been re-registered in the EU, although some essential usage remains. | | | | | |

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| **Bentazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 175 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Basagran) | Oxon | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 700-2000 |
| **Main Crops** | **Main Pests** | | |
| Rice, Soybean, F&V, Maize, Potato, Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :**  dicamba, imazethapyr, nicosulfuron, dichlorprop-p, terbuthylazine, dimethenamid, acifluorfen, MCPA, imazamox | | | | | |
| **Recent History:**  Benzothiadiazinone herbicide, previously one of the leaders in the soybean sector but now superseded by more recent introductions and affected by the success of herbicide tolerant varieties. Product usage has been expanded by introduction in a wide range of crops and in mixture formulations to broaden the spectrum of activity to cover grass weeds. Introduced in mixtures with imazamox as Amplo in Brazil and as Viper in Canada in 2009, with expanded approval for Viper for use on soybeans received in Canada in 2013. Gained US approval in 2016 for use on legumes as Varisto, another mixture with imazamox. Gained EU approval extension until June 2018. In 2017 BASF launched Basagran (bentazone) in India. | | | | | |

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| **Benthiavalicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicides | | Other | <10 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai / Bayer (Valbon) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 25-75 |
| **Main Crops** | **Main Pests** | | |
| Potato, F&V, Vine | Downy mildew, potato blight | | |
| **Main Mixture Partners :** mancozeb, folpet, chlorothalonil, cymoxanil | | | | | |
| **Recent History:**  Oomycete fungicide discovered by Kumiai and also developed under licence by Bayer, with Bayer gaining certain distribution rights for mixtures. The first global introductions were in Switzerland for use on vine and potatoes and in Cuba for use on tobacco in 2004. Launched in the Netherlands, Belgium and the UK in 2005 by the Mitsui & Co. subsidiary Certis Europe where it is used in combination with mancozeb on potatoes. Granted import tolerances from the US EPA in 2006 for vine and tomatoes. Introduced in Japan in 2007 in a mixture with chlorothalonil for use on vegetables as Propose. Introduced by Certis in Italy in 2008 as Valbon for use on vine and tomatoes. Has achieved full EU approval until the end of July 2018, and also approved in Brazil. In 2010 Nippon Soda launched the product in a mixture with cymoxanil as Betofighter in Japan. | | | | | |

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| **Benzobicyclon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <10 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| SDS Biotech (Show-Ace) | None | | |
| **Application** | Timing: | Pre- and early post-emergence | **Rate – (g/ha):** 200-300 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses, sedges and annual broad leaved weeds | | |
| **Main Mixture Partners :**  pyrazosulfuron-ethyl, oxaziclomefone, cafenstrole, daimuron, pyrazoxyfen, azimsulfuron, pyraclonil, flucetosulfuron, carfentrazone, penoxsulam, dimethametryn | | | | | |
| **Recent History:**  Chlorophyll biosynthesis inhibitor with activity against sulfonylurea resistant weeds on both direct seeded and transplanted rice. Intended for use in mixtures with other products for barnyard grass control and utilised in a number of one-shot rice herbicides in Japan, including in ‘Jumbo’ formulations, from several companies such as Sankyo, Kumiai and Bayer, Kaken, Nissan, Ishihara, Mitsui Chemicals and Nihon Nohyaku. Gowan market the product in the USA and key EU countries for control of sedges, grasses and broadleaf weeds. In 2017 Gowan launched Bute (benzobicyclon, halosulfuron) in the USA for use on rice and Avanza (benzobicyclon) was approved in Columbia. | | | | | |

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| **Benzofenap** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <30 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Taipan) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 1600 |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** clomazone, pretilachlor, fentrazamide, benzofenap | | | | | |
| **Recent History:**  Pyrazole broadleaved weed herbicide predominantly marketed in mixtures. A minor product in a very competitive market sector. Became part of the Bayer range following the acquisition of Aventis in 2002. Subsequently acquired from Bayer by OAT Agrio in 2011, with the company assuming all of Bayer’s production and formulation activities regarding the product. OAT Agrio intends to collaborate with other Japanese companies to develop new mixture formulations for the domestic market. | | | | | |

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| **Benzovindiflupyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 300 | 2013 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Solatenol) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Soybean | Asian Rust | | |
| Maize | *Erysiphe graminins* (powdery mildew)*, Helminthosporium, Botrytis,* Apple scab | | |
| **Main Mixture Partners:** azoxystrobin, propiconazole, picoxystrobin, difenoconazole | | | | | |
| **Recent History:**  SDHI fungicide, reportedly with a new mode of action, for the control of Asian rust in soybean as well as other pests in a wide array of crops. Introduced in Paraguay and Bolivia in 2013, and as Elatus (benzovindiflupyr and azoxystrobin) in Argentina and Brazil in 2014. Has achieved registration in the EU, with Elatus approved in France in 2016. Also in 2016, Syngenta expanded its Elatus formulation capabilities at its plant in Paulínia, Brazil. In 2017 Syngenta Canada received a label extension for Aprovia (benzovindiflupyr) to include potatoes as well as a range of horticultural crops. In 2017 DuPont launched Vessarya (benzovindiflupyr, picoxystrobin) in Brazil. Also in 2017 Syngenta gained approval in Ireland and Germany for Elatus Era (benzovindiflupyr, prothioconazole). The UK approved Elatus Era in 2016. | | | | | |

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| **Bicyclopyrone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD | <30 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Acuron) |  | | |
| **Application** | **Timing:** | Pre- and Post-emergence | **Rate – (g/ha):** 37.5-300 |
| **Crops** | **Main Pests** | | |
| Wheat, Barley, Maize, Sugarcane | Grass and Broadleaf weeds | | |
| **Main Mixture Partners:** mesotrione, s-metolachlor, atrazine | | | | | |
| **Recent History:**  New HPPD inhibitor herbicide developed by Syngenta as SYN 449280. In 2014 Syngenta introduced Acuron (bicyclopyrone, mesotrione, s-metolachlor and atrazine) for use on maize. Gained registration approval for use in the USA and Canada during 2015. In 2016 Syngenta launched Talinor (bicyclopyrone and bromoxynil) and Acuron Flexi (bicyclopyrone, mesotrione, S-metolachlor and benoxacor safener) in the USA. In 2017 Syngenta launched Talinor (bicyclopyrone, bromoxynil, cloquintocet) in Australia for use on wheat and barley. | | | | | |

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| **Bifenazate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 60 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Floramite, Acramite) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Ornamentals, Tree nuts, F&V, Pome fruit | Mites | | |
| **Main Mixture Partners :** flufenoxuron, spiromesifen, pyridaben | | | | | |
| **Recent History:**  Introduced in the USA in 1999 as Floramite for use on ornamentals, and for food crop usage as Acramite in 2002. Nissan launched the product in Japan as Mito Kohne for use on fruit in 2000. Also introduced in Argentina in 2002 and Australia in 2003. An SC formulation was introduced in the USA in 2004. Granted Annex 1 Approval in the EU in 2005 with the Netherlands as rapporteur state. The product is sold by Certis in some EU markets, notably France and the Netherlands. Passed to Platform Speciality Products following its acquisition of Chemtura, with the crop protection business now operating as Arysta LifeScience. | | | | | |

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| **Bifenox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO – Diphenyl Ether | <10 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Fox, Modown) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 750-1000 |
| **Main Crops** | **Main Pests** | | |
| Rape, Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** bentazone, mecoprop-p, ioxynil, isoproturon, benfuresate | | | | | |
| **Recent History:**  Ageing broadleaved weed herbicide whose major market is in mixtures on cereals and rape. Now of limited commercial significance. Divested by Aventis to Feinchemie Schwebda in 2000, that company being acquired by Adama in 2002. Granted re-registration in the EU in 2008 with approval until the end of 2018. | | | | | |

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| **Bifenthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 280 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Capture, Talstar, Discipline, Hero) | Amvac, Bharat Rasayan, Adama | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 4-110 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Rice | A wide range of insects. | | |
| Cotton | Bollworm complex, Other Lepidoptera, Boll weevil, Whitefly, Thrips | | |
| Maize | Corn rootworm, Cutworm, Corn stalk borers, Mites. | | |
| **Main Mixture Partners :** tebufenpyrad, amitraz, spinosad, zeta-cypermethrin, imidacloprid, clothianidin, acetamiprid | | | | | |
| **Recent History:**  Broad-spectrum pyrethroid that benefits from activity against certain mite species. Achieved strong growth in the early 2000s mainly due to new registrations, mixture formulations and increased usage in non-crop sectors, particularly termite control, although increasing generic competition has slowed value growth since. A number of generic versions have now been registered in the USA and Japan. FMC has introduced mixtures with zeta-cypermethrin and with imidacloprid. Achieved re-registration in the EU in 2012 following re-submission, although non-crop uses in the EU are no longer permitted. In 2015 FMC’s Hero was included in Monsanto’s Roundup Ready Plus Crop Management Solutions program. In 2015 Vive Crop Protection gained US EPA approval for Bifender, whilst FMC launched Ethos XB (bifenthrin and *Bacillus amyloliquefaciens* strain D747) insecticide/biofungicide. The Canadian Pest Management Regulatory Agency proposed plans in 2017 to phase out FMC’s Capture 240EC. | | | | | |

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| **Bilanafos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Amino acid | <10 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Meiji Seika (Herbiace) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 1000-3000 |
| **Main Crops** | **Main Pests** | | |
| Non-crop | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Structural analogue of glufosinate produced by fermentation, the two products being subject to patent conflict in some markets. This, coupled with the cost of the product, has limited its success in the competitive non-selective herbicide sector. | | | | | |

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| **Bispyribac-sodium** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Others | 80 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Nominee) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 15-45 |
| **Main Crops** | **Main Pests** | | |
| Rice, Turf | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** thiobencarb | | | | | |
| **Recent History:**  Broad-spectrum herbicide for use in rice, co-developed by Kumiai and Valent and now introduced in most of the main rice-producing countries. Distributed by Bayer in Latin America, parts of Asia and Europe, where Annex 1 registration has been achieved. Launched in the USA as Regiment in 2002 by Valent, including promotion as a tank mix with thiobencarb. The product is also used in non-crop situations to stunt the growth of grass, with Australian approval as Nominee for the control of winter grass in turf achieved in 2011. In 2015 Nufarm became the exclusive distributor for Kumiai’s Velocity SP in Canada for use on turf. Insecticides India has launched the active ingredient as Green Label for the control of grasses, sedges and broadleaf weeds in paddy rice. In 2017 Kumiai and PI Industries agreed a joint venture to manufacture and distribute bispyribac-sodium in India. | | | | | |

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| **Bistrifluron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FarmHannong (Hanaro, Xterm) | None | | |
| **Application** | Timing: | Egg hatching and early larval stages. | **Rate – (g/ha):** 50-400 |
| **Main Crops** | **Main Pests** | | |
| F&V | A range of insects including Lepidoptera, whitefly and termites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Originally discovered by HanHwa and subsequently developed by FarmHannong. Active against lepidopteran pests on vegetables and fruit trees, and whiteflies on cabbages and apples. First registered in Korea in 2004. Developed for use in a number of markets including Thailand, India, Bangladesh, Malaysia, Brazil, Colombia, Mexico and Argentina. In 2013 Sumitomo Chemical received Australian approval for termite control. | | | | | |

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| **Bitertanol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Triazole | <10 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Baycor, Sibutol) | None | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 125-600 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cereals, Plantation crops | *Venturia*, *Monolinia*, Bunt, *Fusarium* spp., Septoria leaf spot, Cotton rust | | |
| **Main Mixture Partners :** anthraquinone, imidacloprid, fuberidazole | | | | | |
| **Recent History:**  Broad-spectrum systemic triazole fungicide with preventative, curative and erradicant activity against a wide range of diseases. Major markets are vegetables and fruit, especially pome fruit (scab) and stone fruit (*Monolinia*). Also finds minor use as a cereal seed treatment, mainly in mixtures with other products, notably imidacloprid and fuberidazole. EU approval was withdrawn in 2013, with Bayer deciding not to submit the required confirmatory data for re-registration. | | | | | |

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| **Bixafen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 170 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Aviator Xpro) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cereals | *Septoria*, Rust and others | | |
| **Main Mixture Partners:** prothioconazole, tebuconazole, floxastrobin | | | | | |
| **Recent History:**  Active through the inhibition of succinate dehydrogenase, developed specifically for foliar application to combat speckled leaf blotch and blight. Launched mainly in combinations with tebuconazole and prothioconazole, the co-formulation with prothioconazole reportedly showing excellent control of *Septoria*. Launched in the UK in 2011 with prothioconazole as Aviator Xpro for use on wheat and as Siltra Xpro for use on barley. Aviator has also been granted commercial approval in Germany for use on winter wheat, rye and triticale. Aviator Xpro received approval in Chile in 2011 for use on wheat and barley. In 2017 Aviator Xpro was launched in Australia for use on canola and chickpeas. EU Annex 1 approval was received in 2013. FMC acquired exclusive rights to bixafen from Bayer CropScience to develop and distribute the fungicide for row crops in the US and Canada. | | | | | |

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| **Boscalid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 330 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Pictor, Lance, Endura) | None | | |
| **Application** | Timing: | Foliar, Seed treatment | **Rate – (g/ha):** 285-770 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V, Cereals, Vine, Potato, Turf, Peanuts, Coffee, Ornamentals | Powdery mildew, *Alternaria*, *Botrytis*, *Sclerotinia*, *Monolinia*, Grey mould, soil-borne pathogens such as *Rhizoctonia* *solani*, *Penicillium* and *Fusarium*. | | |
| **Main Mixture Partners :** metrafenone**,** pyraclostrobin, kresoxim, epoxiconazole, dimoxystrobin, metconazole | | | | | |
| **Recent History:**  Nicotinamide fungicide, originally known as nicobifen. Initially developed for use on fruit & vegetables but has subsequently found considerable success for use on oilseed rape (with metrafenone) and cereals (with epoxiconazole). Has also been introduced for use on a wide range of vegetable crops, both alone (as Endura) and in mixtures with pyraclostrobin (as Pristine). The product is manufactured at Guaratingueta, Brazil, with BASF expanding its manufacturing capabilities in 2013. Has Annex 1 approval in the EU. Now one of the leading fungicides worldwide, finding usage in a wide range of countries, primarily in western Europe and the USA, across a broad range of crops, with both foliar and seed treatment usages. BASF supply the product to Incotec for brassica seed treatment usages in the USA. In 2015 BASF launched Pictor (boscalid and dimoxystrobin) in the UK and Efilor (boscalid and metconazole) in Germany, both for use on oilseed rape. In 2016 BASF introduced Lance AG in Canada and Signum (also containing pyraclostrobin) in France. | | | | | |

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| **BPMC (Fenobucarb)** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Osbac) | Sinon, Jin Hung Fine Chemical, FarmHannong | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 500 |
| **Main Crops** | **Main Pests** | | |
| Rice | Green leaf hopper, Leaf miner, Other leaf hoppers, Stinkbug | | |
| **Main Mixture Partners :** buprofezin, chlorpyrifos, diazinon, dimethoate | | | | | |
| **Recent History:**  Broad-spectrum commodity carbamate insecticide, used in many mixtures. Once a mainstay of rice pest control but now of much less significance, the product is mainly used in East Asian markets for general insect control in several crops. | | | | | |

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| **Bromacil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | 45 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Hyvar) | Adama | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 900-27000 |
| **Main Crops** | **Main Pests** | | |
| F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** amitrole, diuron | | | | | |
| **Recent History:**  Uracil herbicide used mainly on citrus for the control of perennial grasses including the difficult to control weed *Agropyron repens*. Also used for total weed and brush control on non-crop land. Amvac acquired DuPont’s global bromacil business in 2015. Has not received re-registration in the EU, although some essential uses remain. | | | | | |

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| **Bromobutide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <30 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Sumiherb) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 600-1800 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** mefenacet, naproanilide, pyrazolynate, daimuron, pyraclonil, bensulfuron-methyl, fenoxasulfone | | | | | |
| **Recent History:**  Niche amide rice herbicide with particular activity against sedges: as a result the majority of sales are achieved from use in mixtures. In 2010 Nihon Nohyaku launched the product in a mixture with daimuron, pyraclonil and bensulfuron-methyl as part of its Ippon D range. In 2014 Kumiai launched the Kumistar range, and Mitsui Chemicals launched Alphapro products (both ranges containing various mixtures of fenoxasulfone, bromobutide and bensulfuron-methyl) for use on rice in the Japanese market. | | | | | |

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| **Bromopropylate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Neoron) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 500-750 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, Plantation crops, Vine, F&V | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Non-systemic contact miticide of limited commercial significance. The product is registered for use in many crop sectors and is also used in the control of parasitic mites in beehives. Always a niche product, it has not been re-registered in the EU. | | | | | |

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| **Bromoxynil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other – Hydroxybenzonitrile | 105 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Buctril) | Nufarm, Albaugh, Adama | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 500-750 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Broadleaved weeds | | |
| **Main Mixture Partners :**  atrazine, ioxynil, MCPP, dicamba, rimsulfuron, MCPA, diflufenican, pyridate, 2,4-D, prosulfuron, pyrasulfotole, thiencarbazone | | | | | |
| **Recent History:**  Broadleaved weed herbicide used mainly on cereals and maize, particularly on cereals in Canada, Australia and the USA. Manufactured through a joint venture with Nufarm. Sales have been affected by the uptake of glyphosate tolerant maize in NAFTA and the product is also subject to increasing generic competition. The product has gained full EU re-registration. Bayer launched the combination products Tundra (bromoxynil, pyrasulfotole and fenoxaprop-P-ethyl) and Thumper Total (bromoxynil and thiencarbazone-methyl) for use on cereals in Canada in 2010, and received US approval for the product in a mixture with pyrasulfotole and thiencarbazone-methyl as Huskie Complete in 2012. In 2016 Syngenta introduced Talinor (with bicyclopyrone) in the USA and Australia in 2017. In 2016, Adama launched Hotshot (with florasulam) in Canada. | | | | | |

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| **Bromuconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Triazole | <10 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Tote) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 250-300 |
| **Main Crops** | **Main Pests** | | |
| F&V | Brown rust, Eyespot, Leaf blotch, Septoria leaf spot, Yellow rust | | |
| **Main Mixture Partners :** tebuconazole | | | | | |
| **Recent History:**  Triazole fungicide of limited commercial significance. The product offers a relatively wide spectrum of disease control in fruit and vegetables. Became part of the Bayer portfolio following the 2002 acquisition of Aventis, although has subsequently passed on to Sumitomo Chemical. The product gained EU registration in 2010 and is currently under review in the USA. | | | | | |

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| **Bronopol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | <10 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Bronotak) |  | | |
| **Application** | Timing: |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Broad spectrum | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Fumigant originally developed by Boots, becoming part of Bayer following the acquisition of Aventis. Not supported through re-registration in the EU market. | | | | | |

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| **Bupirimate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – others | <10 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Nimrod) | Xi’an Modern Pesticide | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 150-750 |
| **Main Crops** | **Main Pests** | | |
| F&V, Vine, Pome fruit | A range of diseases | | |
| **Main Mixture Partners :** tebuconazole | | | | | |
| **Recent History:**  Pyrimidine fungicide for powdery mildew control on pome, stone and soft fruit, vine and some vegetable crops. The major markets are in the European and Mediterranean regions. Mature product of minor commercial importance to Syngenta, who divested the product to Adama in 2000. Gained EU registration to Annex 1 in 2011. | | | | | |

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| **Buprofezin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Others IGR | 110 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Applaud) | SePRO (Talus), FarmHannong, Rallis (Applaud) | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 100-1000 |
| **Main Crops** | **Main Pests** | | |
| Rice | White blackened plant hopper, Brown plant hopper, Green leaf hopper, Other leaf hoppers, | | |
| Cotton, F&V | A wide range of insects | | |
| **Main Mixture Partners :** isoprocarb | | | | | |
| **Recent History:**  Thiadiazine insect growth regulator active via a suppression of ecdysis. Developed particularly for the control of rice brown plant hopper, now also applied to a range of fruit and vegetable crops. Sales have declined in the rice nursery box sector and the product is now subject to generic competition from Chinese production. Rallis launched the product for use on rice in India in 2006. Gained EU re-registration in 2011 with restrictions imposed in 2017 that buprofezin may only be applied to non-edible crops. Engage Agro market buprofezin in Canada, with the first launches in 2014. In 2016 Insecticides India, in conjunction with Nihon Nohyaku’s Hyderabad Chemical subsidiary, introduced the product as Hakko in India. | | | | | |

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| **Butachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 135 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Machete) | Adama, Sinon, Rallis, IpiCi, FarmHannong, Sinochem, Chinese companies | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 1000-4500 |
| **Main Crops** | **Main Pests** | | |
| Rice, Rape, Cotton, F&V | Grasses | | |
| **Main Mixture Partners :** propanil, glyphosate | | | | | |
| **Recent History:**  Commodity pre-emergence grass weed herbicide for use on seeded and transplanted rice. Amongst the leading products for rice weed control in Asia and also used in Latin America. Due to the low cost broad-spectrum weed control the product offers, it has attracted significant generic competition. There is also significant production within China. Sinochem have the Asian rights to the product, covering the businesses and assets in the Philippines, Thailand, Vietnam, Taiwan, India, Pakistan and Bangladesh. The product has not been re-registered in the EU and left the market in July 2003. | | | | | |

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| **Butafenacil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO – Others | <10 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (B-Power, Rebin, Inspire) | None | | |
| **Application** | Timing: | Pre- and early Post-emergence | **Rate – (g/ha):** 75-150 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Perennial crops, Tree nuts, Turf | Annual dicots and small grass weeds | | |
| **Main Mixture Partners :** triasulfuron, glyphosate | | | | | |
| **Recent History:**  Herbicide active through the inhibition of protoporphyrinogen oxidase. Introduced in Switzerland and Australia (in mixtures) in 1998. Approved in Japan and Thailand in 2001. Main current usage is for burndown prior to cereal planting in combination with triasulfuron or glyphosate. Introduced in the USA as Inspire for use as a cotton herbicide and harvest aid (defoliant) in 2003. | | | | | |

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| **Butamifos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Cremart) | None | | |
| **Application** | Timing: | Pre-plant incorporated,  Pre-emergence | **Rate – (g/ha):** 3000-10000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Non-crop | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  A contact organophosphorous herbicide whose main market is for grass weed control on vegetables in Japan. A product of minor commercial significance. | | | | | |

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| **Butralin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | <10 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nufarm (Tamex) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 2400-4800) |
| **Main Crops** | **Main Pests** | | |
| F&V, Tobacco | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** monolinuron | | | | | |
| **Recent History:**  Targeted as a sucker control agent in tobacco, with additional applications for weed control in other crops. The major usage is in Asia on fruit and vegetable crops. Also used in combinations with monolinuron. SDS Biotech introduced the product in Japan in 2004. Has not been re-registered in the EU. | | | | | |

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| **Butroxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | <10 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Falcon) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 40-50 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sunflower | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Cyclohexanedione post-emergence graminicide introduced in some southern hemisphere countries. Has never made a significant commercial impact. | | | | | |

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| **Butylate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tri-Ag (Sutan) |  | | |
| **Application** | Timing: | Pre-plant incorporated | **Rate – (g/ha):** 4500-6900 |
| **Main Crops** | **Main Pests** | | |
| Maize | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  At one time an important herbicide in the US maize sector for pre-plant incorporated grass weed control, however the market has moved towards post-emergence products, no-till, and herbicide tolerant varieties, all of which have had a negative impact on sales. Also applied with the safener dichlormid as Sutan Plus. The product was acquired in 2000 by Cedar, part of TRI Chemicals, who now hold the US registration, the product being distributed by a number of companies including Helm and Microflo. Not registered in the EU. | | | | | |

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| **Cadusafos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Rugby) | None | | |
| **Application** | Timing: | Soil applied | **Rate – (g/ha):** 4000-12000 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, Sugarcane, F&V, Vine | A wide range of insects | | |
| Potato | Nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Has a broad spectrum of activity against nematodes and soil borne stages of insects, with a long duration of activity. As a result the product has a wide range of applications in crops which are susceptible to soil pests, finding most of its sales in plantation crops, particularly bananas and tobacco. Now amongst the top ten sugarcane insecticides in the Brazilian market. The product is not registered in the USA and has been refused re-registration in the EU. | | | | | |

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| **Cafenstrole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| SDS Biotech (Grachitor) | None | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 200-300 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :**  daimuron, pyrazoxyfen, benzobicyclon, azimsulfuron, carfentrazone, flucetosulfuron, benzobicyclon, bensulfuron | | | | | |
| **Recent History:**  Triazole herbicide for pre- and post-emergence control of the important rice grass weed *Echinochloa oryzicola* (barnyard grass). The product is used in some of the leading one-shot rice herbicides in Japan including Joystar and Kusatory Ace. Also used for the control of other grass weeds including *Cyperus difformis* (small umbrella plant). Initially discovered by Chugai Pharmaceutical, the product passed to SDS Biotech in 2001, where it complements daimuron and benzobicyclon. In 2011 Ishihara gained registration in Japan for the product in the Tobikiri range in mixtures with daimuron, pyrazoxyfen and benzobicyclon, as well as Broad-cut in a mixture with azimsulfuron, pyrazoxyfen and benzobicyclon. In 2012 SDS Biotech gained Japanese registration for the product in a mixture with carfentrazone, flucetosulfuron and benzobicyclon as Full Inning Sky. | | | | | |

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| **Captan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite – Phthalimide | 105 | 1951 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Captan) | Adama, Rallis, FarmHannong, Bharat Rasayan | | |
| **Application** | Timing: | Foliar, Seed treatment | **Rate – (g/ha):** 1100-4400 |
| **Main Crops** | **Main Pests** | | |
| Pome fruit, F&V, Plantation crops, Peanuts | A wide range of diseases | | |
| Vine | Downy mildew, Botrytis, Black rot | | |
| **Main Mixture Partners :** carboxin, trifloxystrobin, diazinon | | | | | |
| **Recent History:**  A broad-spectrum contact phthalimide fungicide used mostly on fruit crops. The product benefits from a long duration of action and, similar to other multisite contact fungicides, no resistance build up. Originally discovered by Standard Oil (Chevron), captan was acquired by Tomen from Zeneca. Re-introduced in Germany in 2001 with new data, having been banned there in 1986. Re-registration in the EU has been accepted, with approval currently extended until July 2018. In 2008 Chemtura (now part of Platform Speciality Products under the Arysta LifeScience trade name) introduced Enhance (captan, imidacloprid and carboxin) as a seed treatment for cereals, soybeans and dry beans. In 2011 Arysta completed an expansion of a new captan production line at its facility in Noguères, France and in 2012 received registration for the product in the market as Sigma. Bayer also sells the product with trifloxystrobin in Portugal as Flint Plus for use on pomes. Adama received US EPA approval in 2015 for its Captan Gold 4L for use on strawberries, tree fruit and specialty crops. | | | | | |

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| **Carbaryl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <30 | 1956 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tessenderlo Kerley (Sevin) | Atul | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 400-22500 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V, Pome fruit, Maize, Rice, Cereals | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity broad-spectrum insecticide with many crop outlets. Tessenderlo Kerley Inc acquired the global crop protection assets of the product from Bayer, with Tessenderlo’s NovaSource crop protection wing managing the business. Bayer retained the non-crop uses for the product. Re-registration in the EU has been refused, lawn and animal health usages in Canada have been withdrawn, and all uses except cottonseed, forage and fodder crops have been cancelled in Australia. The main country markets for the product are now the USA and several countries in Asia, notably India and Thailand. The trade and use of carbaryl will be banned in India from 1st January 2018. | | | | | |

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| **Carbendazim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Benzimidazole | 150 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Bavistin) | DuPont, Bayer, Gharda, Sinon, Adama, Meghmani, Chinese companies | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 100-300 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Brown spot, Septoria leaf spot, Leaf spot, Leaf blight, Powdery mildew | | |
| F&V, Cereals, Rice, Cotton | A wide range of diseases | | |
| **Main Mixture Partners :**  epoxiconazole, thiram, flusilazole, flutriafol, carbofuran, triadimefon, cyproconazole, propiconazole, vinclozolin, iprodione, prochloraz, fenbuconazole, sulphur, chlorothalonil, mancozeb, tebuconazole, kresoxim-methyl | | | | | |
| **Recent History:**  At one time a leading cereal fungicide product, however due to resistance development the importance of the treatment has declined and it is now predominantly used in mixtures. The product is now produced by several manufacturers and is widely marketed by a large number of companies. Re-registration in the EU has been refused and several uses have now been phased out in Australia. In Brazil, FMC market the product as Locker, a mixture with kresoxim-methyl and tebuconazole for Asian Soybean Rust control, and Rotam have introduced Tebuzim, also containing tebuconazole, for use on soybeans. BASF divested its Bavistin range in India to Crystal Crop Protection in 2016. | | | | | |

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| **Carbetamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Legurame, Carbetamex) | None | | |
| **Application** | Timing: | Pre- and Post-emergence | **Rate – (g/ha):** 2000-4000 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V | Grasses, Broad leaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum carbamate herbicide, whose major use is for the control of annual grasses and some broadleaved weeds on oilseed rape (post-emergence) and also peas, beans and fruit. As part of the consolidation of Aventis the product was divested to Feinchemie Schwebda in 2000, and has subsequently been acquired by Adama. Has achieved re-registration in the EU. | | | | | |

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| **Carbofuran** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 190 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Furadan) | Bayer, Adama, Rallis, Dow, FarmHannong, Sinon | | |
| **Application** | Timing: | Foliar,  Soil applied,  Seed treatment | **Rate – (g/ha):** 150-11000 |
| **Main Crops** | **Main Pests** | | |
| Rice, Sugarcane, F&V | A wide range of insects | | |
| Maize | Corn rootworm, European corn borer, Armyworm, Flea beetle, Grasshoppers, Seedcorn maggot, Wireworm, Aphid, Grasshoppers, Mites. | | |
| **Main Mixture Partners :** zinc-oxide, carbendazim, triadimefon | | | | | |
| **Recent History:**  Commodity carbamate insecticide/nematicide/miticide with a broad spectrum of crop applications, particularly against soil pests. The product has been the subject of regulatory action limiting the use of granular formulations. Regulatory actions have impacted sales of the product; all tolerances were revoked in the USA in 2009; China halted new applications for field testing, registration and manufacturing permits for the product in 2011 whilst use on sugarcane was banned in the country in 2015; banned in Peru in 2011; and re-registration has been refused in the EU. Bayer has discontinued production of the product at its facilities in Institute, WV and Woodbine, GA. In October 2017 the Brazilian authorities banned carbofuran on all crops, with a six month phase out for bananas, coffee and sugar cane. | | | | | |

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| **Carbosulfan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 90 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Marshal) | FarmHannong, Sinon | | |
| **Application** | Timing: | Soil applied | **Rate – (g/ha):** 150-3000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Brown plant hopper, Green leaf hopper, Leaf beetle, Leaf miner, Water weevil | | |
| Cotton, F&V | A wide range of insects | | |
| **Main Mixture Partners :** probenazole, bifenthrin | | | | | |
| **Recent History:**  Analogue and precursor of carbofuran, developed for markets where the original product was restricted due to handling problems. Once a major product in Japan for control of water weevil, where it is marketed by Nissan, and still significant in South Korea, however sales have declined from peak levels due to competition from new introductions. In 2010 FMC expanded its manufacturing capacity for the product in Brazil. Re-registration in the EU has been refused. | | | | | |

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| **Carboxin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 50 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Vitavax) | Bayer, Sundat, Jin Hung | | |
| **Application** | Timing: | Seed treatment, Foliar | **Rate – (g/ha):** 1100-1400 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V, Plantation crops, Peanuts, Rice | Bunt, Seedling blight, Stem rot, Southern blight, Cotton damping off, Head smut | | |
| Soybean | Pot and Stem blight | | |
| **Main Mixture Partners :** thiram, maneb, captan | | | | | |
| **Recent History:**  Systemic seed treatment used on a wide range of crops and also as a foliar fungicide for peanuts. Seed treatment use is often in combinations with other products, notably thiram. Despite the onset of generic competition, sales remain relatively stable. In 2008 Chemtura (now part of Platform Speciality Products under the Arysta LifeScience trade name) introduced Enhance (captan, imidacloprid and carboxin) as a seed treatment for cereals, soybeans and dry beans. Achieved re-registration in the EU. In 2016 Arysta LifeScience received approval from the USA EPA for its Rancona V PD fungicide seed treatment for use on peanuts. In 2017 Arysta launched Rancona V 100 Pro in the US for soybean seed treatment. | | | | | |

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| **Carfentrazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO – Others | 130 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Aurora, Affinity, Aim) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 4-35 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Soybean, Vine, Potato, Cotton | Broadleaved weeds | | |
| **Main Mixture Partners :** flupyrsulfuron, quinclorac, flucetosulfuron, pyroxasulfone, chlorimuron-ethyl | | | | | |
| **Recent History:**  Phenyl triazolone herbicide for broadleaf weed control, originally licensed out for marketing in cereals in Europe to DuPont, predominantly in a mixture with flupyrsulfuron as Lexus Class providing broad-spectrum weed control. Carfentrazone has also been introduced in Asia and the USA for use on maize and also on rice as Shark. Registered in Canada where it is distributed by Nufarm. It is used in the USA in combination with glyphosate for pre-plant weed burndown and as a cotton defoliant. A formulation for use on ornamental lawns and turf grass was introduced in 2003. In the same year full approval was gained in the UK for use on potatoes. Approved in France in 2004 for use as a potato defoliant. A new formulation, Shark EW, was approved in the US in 2006 for year-round use on trees and vines. In 2010 FMC launched Broadhead and SquareOne in the USA, two new mixture products also containing quinclorac. Has achieved Annex 1 approval in the EU and received provisional approval in Brazil in 2011. In 2012 Ishihara gained Japanese registration for the product in a mixture with flucetosulfuron as Fullcharge Sky for use on rice. FMC received approval in Canada in 2014 for Focus, also containing pyroxasulfone, for use on soybeans. Also in 2014 DuPont launched Expression Pack (carfentrazone-ethyl and chlorimuron-ethyl) in Argentina. | | | | | |

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| **Carpropamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other – Carboxamide | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Solaza, Win) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 75-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| **Main Mixture Partners :** imidacloprid, thifluzamide | | | | | |
| **Recent History:**  Rice blast fungicide combined with imidacloprid as Win/Admire in Japan for insect and disease control in nursery boxes which was initially introduced to significant commercial success; however, this product has now been superseded by more recent introductions. Thifluzamide has since been added to this in a mixture to provide sheath blight control. | | | | | |

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| **Cartap** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 115 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Padan) | Jin Hung, Sundat, Punjab Chemicals | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 400-4000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Green leaf hopper, Leaf beetle, Leaf miner, Leaf rollers, Stem borer, Water weevil | | |
| F&V, Potato | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity insecticide, primarily developed for use on rice. Use has also been broadened to other crop sectors, the most important of which are fruit and vegetables in a number of markets. Not re-registered in the EU. | | | | | |

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| **Chlorantraniliprole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 1,365 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Premio, Dermacor, Corozen) | Syngenta, under license for use in mixtures (Durivo, Voliam, Besiege, Ampligo) | | |
| **Application** | Timing: | Foliar, Soil applied, Seed treatment | **Rate – (g/ha):** 35-50 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Rice, Cotton, Maize, Pome fruit, Sugarcane Potato, Cereals | Chewing insects, primarily lepidoptera species | | |
| **Main Mixture Partners :** thiamethoxam, lambda-cyhalothrin, abamectin, probenazole | | | | | |
| **Recent History:**  Also known as Rynaxypyr®. Perceived to be one of the most active products available for lepidoptera control and has achieved significant sales growth since its introduction in 2008. Similar structure to phenylpyrazoles but different mode of action, the blocking of ryanodine receptors. Now introduced in most major markets, and has received Annex 1 registration in the EU. The main crop uses are on soybeans, fruit & vegetables, rice, cotton and maize. Also finds use as a seed treatment and in non-crop situations.  Syngenta has licenced rights to the product for use in mixtures, with the main brands being Voliam Xpress, Ampligo and Besiege with lambda-cyhalothrin; Durivo with thiamethoxam; and Voliam Targo with abamectin. In 2012 Syngenta acquired DuPont’s Professional Products business, including the chlorantraniliprole-based products Acelepryn (for turf) and Altriset (termite control). Hokko sells the product in a mixture with probenazole as Dr Oryze-Ferterra for rice in Japan. Dhanuka Agritech launched Cover in India in 2015 for use on several crops including rice, soybean and sugarcane. Arysta LifeScience market the product as Prevathon in Myanmar. Also during 2015 DuPont received registration in Brazil for Dermacor seed treatment for the control of soil and foliar pests in soybean and maize. In 2016 DuPont gained Canadian registration for Lumivia seed treatment for use on maize. In 2017, DuPont and Arysta announced that they would collaborate on developing combination products containing DuPont’s chlorantraniliprole and Arysta’s acetamiprid. Shortly after this, DuPont announced that it was divesting chlorantraniliprole to FMC. | | | | | |

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| **Chlorethoxyfos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <5 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Fortress) | Gowan | | |
| **Application** | Timing: | Soil applied | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Maize | Corn rootworm, Cutworm, Wireworm | | |
| **Main Mixture Partners :** bifenthrin | | | | | |
| **Recent History:**  Soil applied phosphorothioate insecticide active against many of the major soil pests of maize. Developed by DuPont and first launched in the USA in 1995; however it was never a major product in the maize insecticide market and was divested to Amvac in 2000. Sales have benefited recently from usage in Amvac’s SmartBox application system. | | | | | |

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| **Chlorfenapyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Others | 80 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Intrepid, Pirate) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 125-500 |
| **Main Crops** | **Main Pests** | | |
| F&V | Bollworm, Mites, Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Insecticide/miticide offering a novel mode of action, active forms of chlorfenapyr are responsible for the uncoupling of oxidative phosphorylation and the disruption of energy creation. The product is based on dioxapyrrolomycin, an isolate from *Streptomyces* fermentation. Widely used in Japan (as Kotetsu) and in most of East Asia for use on cotton, fruit and vegetables. The product is registered in the USA for use on ornamentals as Pylon, and as a termiticide, benefiting from BASF’s greater exposure in the sector following the acquisition of fipronil. Has not been re-registered in the EU, the main markets are Asia and Latin America. BASF, the London School of Hygiene and Tropical Medicine (LSHTM) and the Innovative Vector Control Consortium (IVCC) are developing malaria prevention products based on chlorfenapyr. Received approval for use in Canada in 2014. | | | | | |

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| **Chlorfenvinphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Birlane) |  | | |
| **Application** | Timing: | Soil applied,  Foliar | **Rate – (g/ha):** 200-4000 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V | Wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus insecticide with both soil and foliar activity and also with applications in public health (mosquito control) and animal health (tick control on cattle and sheep). Now a mature product of limited significance. Has not been re-registered in the EU. | | | | | |

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| **Chlorfluazuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 35 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Atabron) | Syngenta | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 10-25 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Plantation crops, Cotton | A wide range of insects. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad spectrum insect growth regulator active against Lepidopteran larvae, especially *Spodoptera littoralis*, and chewing pests on fruit and vegetables, soybeans and cotton. The product reportedly offers greater persistence than many competing IGRs. Licensed out by Ishihara to Zeneca and Novartis, passing to Syngenta following its formation. Has not been re-registered in the EU. The Chinese company Nanjing Redsun have invested in the construction of a manufacturing facility for the product. In 2014 Arysta LifeScience received authorisation in Brazil for Atabron to control earworms on cotton and soybeans. | | | | | |

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| **Chloridazon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other – Pyridazine | <30 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Pyramin) | Oxon, Sumitomo | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 2000-2600 |
| **Main Crops** | **Main Pests** | | |
| Sugarbeet | Broadleaved weeds | | |
| **Main Mixture Partners :** quinmerac, phenmedipham | | | | | |
| **Recent History:**  Mature pyridazine herbicide for broadleaved weed control that still holds an important position in the sugarbeet sector. Sales have been assisted by the introduction of mixture formulations with quinmerac (Rebell, Fiesta and Zepplin) in most major sugarbeet markets. Accepted for re-registration in the USA in 2005, with some spray drift and re-planting restrictions. EU re-registration has also been achieved. Sumitomo Corporation, through its Summit Agro International subsidiary, acquired the Japanese manufacturing, marketing and distribution rights to chloridazon from BASF. | | | | | |

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| **Chlorimuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | 90 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Classic, Canopy) | Atul, Chinese Companies, Nortox | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 9-13 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** sulfentrazone, flumioxazin, 2,4-D | | | | | |
| **Recent History:**  Soybean herbicide which also finds some limited sales in mixtures for use on rice. The major markets for the product are the USA and Brazil; however it is now subject to significant generic competition. Sales have been affected by the success of the imidazolinones and also by the impact of herbicide tolerant varieties. FMC has introduced mixtures with sulfentrazone as Authority XL and Authority Maxx for the control of glyphosate resistant weeds on soybeans. Valent USA received approval in the US for Fierce XLT (pyroxasulfone, flumioxazin and chlorimuron-ethyl) for use on soybean in 2014. DuPont’s Blend, a mixture of chlorimuron and metribuzin, gained approval for use in the USA during 2015. Helm gained US approval in 2016 for Sheridan 25WG for broadleaf weed and grass control in soybean, peanuts and non-crop applications. | | | | | |

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| **Chlormequat** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 80 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Cycocel) | Adama, Nufarm, Taminco | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 700-1400 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Cotton | n.a. | | |
| **Main Mixture Partners :** mepiquat-chloride, ethephon, choline-chloride, imazaquin, metalaxyl | | | | | |
| **Recent History:**  One of the leading plant growth regulators used for limiting stem growth in cereals to prevent lodging. The major markets are in Western Europe where sales are related to planted area. Now a commodity product and manufactured by a number of companies. Deemed eligible for re-registration in the US in 2007, providing certain risk mitigation measures are followed. Has achieved Annex 1 approval in the EU, with usage extended to non-edible crops, including ornamentals and turf, in 2010. In 2014 Engage Agro introduced chlormequat chloride as Manipulator for use on spring and winter wheat in Canada. | | | | | |

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| **Chloropicrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 106 | 1908 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Dorocrawl, Chloropicrin) | Nippon Kayaku, Arysta LifeScience | | |
| **Application** | Timing: | Soil applied, Fumigant | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice, F&V, Tobacco, Non-crop | Insects, Diseases, Nematodes, Weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity fumigant with activity against all biological pests via metabolic dechlorination on reaction with biological thiols. The product is mainly used for the control of soil pests, and also pests in stored grain. Recent sales have benefited from the product’s market position as a methyl bromide replacement. Refused re-registration in the EU, but re-registered in the USA in 2008 with risk mitigation procedures. Re-registered for use in Canada following special review in 2016. | | | | | |

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| **Chlorothalonil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite – Phthalimide | 330 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Bravo) | Caffaro/Vischim, SDS Biotech, Veterans, Gharda, FarmHannong, Sinon, Adama, Sipcam | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 850-2500 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Septoria leaf spot, Net blotch, Leaf blotch | | |
| Potato | Early blight, Potato blight | | |
| F&V, Rice, Pome fruit, Peanuts | A wide range of diseases | | |
| **Main Mixture Partners :**  azoxystrobin, pyrimethanil, propamocarb, fluquinconazole, cymoxanil, carbendazim, mancozeb, metalaxyl-m, propiconazole, cyproconazole, azoxystrobin, penthiopyrad | | | | | |
| **Recent History:**  Broad-spectrum commodity contact fungicide whose major markets are on peanuts in the USA and fruit and vegetables in Asia. Significant sales are also achieved in mixtures for use on cereals. Despite its age, sales have been maintained through applications in many different sectors, although the product is subject to significant generic competition. Benefited from use in combination with azoxystrobin to provide cover of *Septoria* on cereals. In the USA Syngenta has introduced the mixture formulations Renown (with azoxystrobin) for use on turf and Daconil Action (with acibenzolar). In 2012 the US EPA proposed approval for DuPont’s Treoris, a mixture of the product with penthiopyrad, for use on fruit and vegetables and canola. Bravo ZN received an extension for use on a further 30 crops in Canada in 2015. Has received full Annex 1 re-registration in the EU. In 2015 Gowan received registration in the USA for Zing! (chlorothalonil and zoxamide) for use on tomatoes, potatoes, cucurbits and onions. In 2016 the SipcamRotam joint venture launched a spray dried granule formulation of Echo Ultimate 825 in the USA. [**In June**](https://agrow.agribusinessintelligence.informa.com/AG027869/Amvac-completes-Adama-product-purchases) 2017, Amvac acquired chlorothalonil, from Adama as a [**condition of**](https://agrow.agribusinessintelligence.informa.com/AG027501/US-FTC-demands-US-assets-divestiture-for-ChemChinaSyngenta-approval) the US Federal Trade Commission’s approval of ChemChina’s takeover of Syngenta. At that time, Adama took over Syngenta’s chlorothalonil-based fungicides, Bravo, Bravo Weather Stik, Bravo Ultrex and Bravo ZN. | | | | | |

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| **Chlorotoluron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | 45 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Tablo, Dicuran) | Nufarm, UPL | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 1500-3500 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** triasulfuron, diflufenican | | | | | |
| **Recent History:**  Commodity urea herbicide for both broadleaf and grass weed control in cereals, including blackgrass (*Alopecurus myosuroides*). Sales are down from peak levels, however the product offers a low-cost broad-spectrum option for weed control. Has received re-registration in the EU until the end of October 2018, although usage in France has been restricted since 2003 due to groundwater concerns. | | | | | |

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| **Chlorpropham** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <30 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Aceto (Sprout Nip) | Xeda, Decco | | |
| **Application** | Timing: | Post-harvest | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Potato | Inhibits sprouting | | |
| **Main Mixture Partners :**  trifluralin | | | | | |
| **Recent History:**  Also known as CIPC. A sprout suppressant used in bulk potato storage, widely used in several country markets including the USA, Canada, the EU and Australia. | | | | | |

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| **Chlorpyrifos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 670 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Dursban, Sabre, Lorsban) | DE Nocil, FMC, Gharda, Adama, Excel Crop Care, AIMCO, Mitsui Chemicals, Atanor, Coromandel, Sinon. Bharat Rasayan, Heranba, Meghmani, Jubilant, Redsun, UPL | | |
| **Application** | Timing: | Foliar, Soil applied | **Rate – (g/ha):** 250-3500 |
| **Main Crops** | **Main Pests** | | |
| Rice, Soybean, Plantation crops, F&V, Cereals, Pome fruit | A wide range of insects/ mites and nematodes. | | |
| Maize | Bill bug, Corn rootworm, Corn stalk borers, Cutworm, European corn borer, Armyworm, Flea beetle, Seed corn maggot, Wireworm, Grasshoppers, Mites, Aphids | | |
| Cotton | Bollworm, Other Lepidoptera, Boll weevil, Thrips, Aphids | | |
| **Main Mixture Partners :**  cypermethrin, beta-cypermethrin, deltamethrin, dimethoate | | | | | |
| **Recent History:**  At one time the largest selling insecticide in the world and still widely used in many crop sectors. Dow AgroSciences still dominates sales, however the product is a true commodity with many manufacturers. Residential uses in the USA have been lost and non-agricultural uses in Europe phased out by Dow, although the product has been accepted for agricultural purposes and has received Annex 1 re-registration in the EU, where sales have recently benefitted from other organophosphates leaving the EU market. Chlorpyrifos is a government-sanctioned replacement in China for other insecticides which are deemed to be of high toxicity. In 2011 the Indian authorities cancelled Dow’s registration for the product as Dursban and Nurelle (a mixture with cypermethrin). In 2015 the US EPA proposed a ban on chlorpyrifos in the country. In 2015 Dow launched Arben, a mixture with sulfoxaflor, in China for the control of rice stem borers, aphids, thrips and rice plant hoppers. | | | | | |

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| **Chlorsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | 70 | 1982 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Glean) | Chinese Companies | | |
| **Application** | Timing: |  | **Rate – (g/ha):** 8-26 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Broadleaved and some grass weeds | | |
| **Main Mixture Partners :** thifensulfuron-methyl, dicamba, metsulfuron-methyl, sulfometuron | | | | | |
| **Recent History:**  One of the first sulfonylurea introductions, and at one time the leading sulfonylurea for cereals, although now superseded by more recent introductions. Still finds usage in a number of mixture formulations. Generic competition has impacted sales. Achieved re-registration in the EU, however all registrations in China have been prohibited. Landmark, a combination with sulfometuron, is used in forestry, turf and other non-crop markets. In 2017 FMC agreed to acquire chlorsulfuron-methyl along with a package of other insecticides and herbicides from DuPont as part of the US and EU requirement for the DowDuPont merger. | | | | | |

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| **Chlorthal** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Dacthal) | Ishihara | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 5000-17000 |
| **Main Crops** | **Main Pests** | | |
| F&V | Grass and Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Mature broadleaved weed residual herbicide of limited commercial significance. The major markets are on fruit and vegetables, often in mixtures with other products. The label in the USA was passed to Amvac from Zeneca in 2000. The product has not been re-registered in the EU. In 2005 Amvac requested the cancellation of 28 crops from the herbicide label due to EPA groundwater concerns. | | | | | |

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| **Chromafenozide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other IGR | <10 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals, Nippon Kayaku (Matric) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 25-100 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice leaf holder, Rice Stemborer | | |
| Tea, Forestry | Codling moth, Grape berry moth, Tomato pinworm, Other Lepidopteran larvae | | |
| **Main Mixture Partners :** clothianidin | | | | | |
| **Recent History:**  Recommended for use against lepidopteran pests, particularly on rice against borer, leafroller, skipper and green caterpillar; and also apples, leeks, sugarbeet and tea against tortrix, armyworm, leafrollers and mugwort looper. Introduced in Japan, Thailand and Indonesia in 2000, with subsequent registrations being achieved in a number of other country markets in Asia and Latin America. Introduced in Germany for use on fruit and vines in 2003 by Speiss-Urania. Launched in Brazil in 2005 by the Arysta subsidiary Hokko do Brasil. The product was co-developed with Sankyo (now Mitsui) for introduction in France, Germany, Spain, Italy and other European and South East Asian countries in 2008, although sales remain relatively limited. Has achieved Annex 1 approval in the EU. | | | | | |

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| **Cinidon-ethyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO – Others | <10 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Lotus, Bingo) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 50 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** 2,4-D, MCPP-P, dichlorprop-p, tribenuron-methyl | | | | | |
| **Recent History:**  Phenylphthalimide herbicide active via PPO inhibition. Targeted for use in mixtures with residual herbicides (often phenoxies) to provide improved *Gallium aparine* control. Introduced in Europe in 1999, although has now been phased out of this market. Further introductions have taken place in other country markets including in China and Africa as Vega, Orbit and Solar. | | | | | |

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| **Cinosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS-Sulfonylurea | <10 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Setoff) |  | | |
| **Application** | Timing: | Post emergence | **Rate – (g/ha):** 100 – 150 |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaf weeds and sedges | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum sulfonylurea herbicide for use on rice, uptake for usage in ‘one-shot’ herbicides has been limited hence commercial impact has been minimal. Major markets for the product were in Italy and Spain; however the product was not supported through re-registration and has left the EU market, with most sales now taking place in Asia. | | | | | |

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| **Clethodim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | 260 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical / Valent (Select, Select Max) | Arysta LifeScience, Adama | | |
| **Application** | Timing: | Post emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Soybean, Rape, F&V, Sunflower, Cotton, Sugarbeet | Grasses | | |
| **Main Mixture Partners :** fenoxaprop-P-ethyl | | | | | |
| **Recent History:**  Cyclohexanedione graminicide for use in broadleaf crops. Introduced in 1987 by Chevron for use in soybeans in the USA. The product is now sold by Sumitomo Chemical’s Valent subsidiary following their takeover of the joint venture with Chevron. Sales on soybean in the USA, Argentina and Brazil were affected by the adoption of Roundup Ready soybean; however sales in the last decade have benefited from usage in Roundup Ready soybeans to control volunteer Roundup Ready maize through a programme organised by Monsanto in the USA. The product is also used on a range of other broadleaf crops such as oilseed rape, sunflower, cotton and sugarbeet, and is also sold in Europe under licence. Now subject to generic competition, notably from Adama. In 2010 clethodim achieved re-registration in the EU and also entered Monsanto’s Roundup Ready Plus programme. Arysta has introduced the product in India, and recently received new registrations in Europe: as Centurion Max in the UK in 2013, to be distributed by Interfarm; and for Centurion Plus in the Netherlands in 2014, to be distributed by Certis Europe. Adama received approval for Poquer for use on soybeans in Brazil in 2014, with use extended to sunflower, apple, maize, grapevines and wheat in 2016. Also in 2016 Arysta launched the product as Select One Pack in Brazil. | | | | | |

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| **Clodinafop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 165 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Topik) | Gharda, Atul, Meghmani | | |
| **Application** | Timing: | Post emergence | **Rate – (g/ha):** 40-80 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses | | |
| **Main Mixture Partners :**  cloquintocet-mexyl, cloquintocet, thifensulfuron-methyl, tribenuron-methyl, pinoxaden, 2,4-D, clodinafop-propargyl, fluroxypyr | | | | | |
| **Recent History:**  Aryloxyphenoxypropionate graminicide, with activity against blackgrass (*Alopecurus* spp.), wild oats (*Avena* spp.) and other annual grass weeds on cereals (except barley). The product was rapidly accepted as an isoproturon replacement to become one of the leaders in the cereal herbicide sector, particularly due to exceptional activity against wild oats and also showing good activity against late germinating weeds. The product has gained significant market share in India and Canada, although now subject to significant generic competition resulting in price erosion, particularly in India. Has received full Annex 1 re-registration in the EU. Complemented by pinoxaden in the Syngenta portfolio, although there is some cross-over in activity. Mixture products with pinoxaden have been introduced, including Traxos in Canada and Spain, and TraxosTwo (also containing clodinafop and fluroxypyr) in Canada for use on wheat. Syngenta and Arysta LifeScience have an agreement whereby Syngenta supply clodinafop to Arysta, with Arysta launching clodinafop-propargyl as NextStep NG for cereals in the USA in 2011. | | | | | |

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| **Clofentezine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Apollo) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 32-160 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V, Pome fruit, Vine | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Specific miticide with particular activity against European red spider mite. Adama purchased the molecule in 2000 on the formation of Aventis. The primary crop market for the product is apples; however registrations have been expanded to cover all of the main miticide sectors. EU re-registration has been achieved, under certain risk mitigation measures. | | | | | |

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| **Clomazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | 300 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Command, Gamit-Star) | Adama (Kalif) | | |
| **Application** | Timing: | Pre-plant incorporated,  Pre-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Rape, Rice, Cotton, Soybean, Potato, F&V, Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** metazachlor, dimethachlor, ametryn, napropamide, sulfentrazone, propanil, metribuzin | | | | | |
| **Recent History:**  Developed as a pre-plant incorporated or pre-emergence soybean herbicide, however sales are now led by sugarcane, oilseed rape, rice and cotton. A mixture with sulfentrazone has been introduced in the USA for use on soybeans. RiceCo sell the product in Asia Pacific for use on rice in a pre-mix with propanil. Albaugh introduced the product as Clomate in the UK for use on potato and oilseed rape, whilst Belchim introduced the product in Italy in a mixture with metribuzin as Metric for use in horticulture. EU re-registration has been achieved. In 2016 Arysta introduced Proponit Duo (with propisochlor) in Ukraine for pre-emergence use on winter and spring oilseed rape. | | | | | |

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| **Clomeprop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Phenoxyacetic acid | <10 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Yukahope) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 500 |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** fentrazamide, bensulfuron, oxaziclomefone | | | | | |
| **Recent History:**  Broad-spectrum auxin type rice herbicide which is mainly used to provide the broadleaf control element in one-shot mixture products, the most significant being Mr Homerun in Japan. Formerly a Mitsubishi product which passed to Aventis Yuka Agro, and subsequently to Bayer following the company’s purchase of Aventis in 2002. | | | | | |

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| **Clopyralid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 190 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Lontrel) | UPL | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize, Rape, Sugarbeet | Broadleaved weeds | | |
| **Main Mixture Partners :** imazamox, imazethapyr, MCPP, picloram, benazolin, fluroxypyr, MCPA, acetochlor, flumetsulam | | | | | |
| **Recent History:**  Pyridine herbicide for post-emergence control of broadleaved weeds, mainly used in cereals, but with a wide range of other crop applications, notably rape and maize. The product is incorporated in many mixtures, including recently introduced formulations. Despite its age the product is still an important part of Dow AgroSciences’ herbicide portfolio; however it is coming under increasing pressure from generic competition. Some usages have also been supplanted by Dow’s more recently introduced, patented and more active product aminopyralid. In 2002 usage on residential turf in the USA was dropped, although a new formulation for use on fruit & vegetables has since been introduced as Stinger. Launched in the UK in 2004 as Galera for use on winter oilseed rape. In 2007 Dow received US EPA approval for SureStart, containing clopyralid with acetochlor and flumetsulam, for early season control of broadleaf weeds in Roundup Ready maize. In 2008 BASF received Canadian approval for Tensile, a mixture with imazamox, for use on imidazolinone tolerant Clearfield canola. In 2010 Monsanto added the product TripleFlex to its portfolio (acetochlor, flumetsulam and clopyralid) for pre- and post-emergence control of broadleaf weeds and grasses in maize in the USA. The product has received full Annex 1 re-registration in the EU. In 2015 Dow received US EPA registration for PerfectMatch (pyroxsulam, fluroxypyr and clopyralid) for use on spring and durum wheat and for Resicore (clopyralid, mesotrione and acetochlor) for use on maize. | | | | | |

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| **Cloransulam-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Other | 115 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Pacto, Firstrate) | None | | |
| **Application** | Timing: | Ppi, Pre- or Post-emergence | **Rate – (g/ha):** 17.5 – 53 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Broadleaved weeds | | |
| **Main Mixture Partners :** flumioxazin, sulfentrazone | | | | | |
| **Recent History:**  A relatively late entrant into the soybean herbicide sector, and sales have suffered from the uptake of Roundup Ready varieties, particularly in Brazil. A formulation including Valent’s flumioxazin was introduced as Gangster in 2003. FMC entered into a supply agreement with Dow AgroSciences in 2007 for use of the product in mixtures with sulfentrazone as Authority First DF. Dow has also introduced a mixture with sulfentrazone as Sonic and a mixture with flumioxazin as Surveil in the USA. | | | | | |

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| **Clothianidin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 380 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Dantotu) Bayer (Poncho) | Arysta LifeScience | | |
| **Application** | Timing: | Soil, foliar,  Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Maize | Corn Rootworm, Cutworm, Wireworm. Flea beetle, Seedcorn maggot | | |
| Rape, Rice, F&V, Potato | Broad range of sucking and biting pests | | |
| **Main Mixture Partners :** diclocymet, validamycin, ferimzone, phthalide, cartap, carpropamid, beta-cyfluthrin, *Bacillus firmis* | | | | | |
| **Recent History:**  Co-developed by Takeda and Bayer, and marketed by the Sumitomo/Takeda joint venture in Japan, where it was introduced in 2002 in mixtures for use on rice, and as Fullswing for turf. On introduction, offered additional spectra of control compared to available neonicotinoids, with particular applications in seed treatment (rice nursery box). Introduced by Bayer as the seed treatment Poncho in 2003 for soil pest and corn rootworm control. Bayer has launched a number of combination products for seed treatment use, including Poncho/Votivo with *Bacillus firmus* on range of crops including maize, soybeans and cotton; with penflufen for canola in the USA and potatoes in Canada; and with beta-cyfluthrin for sugarbeet in the UK. Poncho/Votivo is part of Monsanto’s Acceleron seed treatment brand. Annex 1 approval has been received in Europe. Bayer plans to develop a new version of Poncho / Votivo with enhanced yield potential and insect resistance in corn. Introduced by Arysta in Mexico in 2004, in the USA in 2005 as Arena (turf) and Clutch (pome fruit), and in the USA in 2012 with bifenthrin as Aloft for turf. In 2007 Valent took over Arysta’s brands in the crop and ornamental sectors in the USA, with Valent introducing Belay in 2008 for use on potatoes and Clutch for use on vines. Valent has since launched a number of seed treatment products containing clothianidin, including with metalaxyl for sugarbeet, with metconazole for cereals, and with ipconazole, metalaxyl and ethaboxam for soybeans. In 2016 Sumitomo launched the seed treatment Inside FS in Brazil for use on cotton, maize and soybeans, with the product to be distributed by Nufarm Brasil. | | | | | |

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| **Copper Fungicides** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite – Inorganic | 560 | 1885 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** **Cu** | |
| IQV | Isagro, BASF, Bayer, Syngenta, Caffaro, Dow, Cuproquim, UPL, SePRO, FarmHannong, Rallis, Mitsui & Co | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 600-4500 |
| **Main Crops** | **Main Pests** | | |
| Vine | Downy mildew, Black rot | | |
| Potato | Early blight, potato blight | | |
| F&V, Plantation crops, Pome fruit, Rice | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Copper is utilised in many forms in a variety of broad-spectrum commodity fungicides, notably as copper sulphate in Bordeaux mixture, copper hydroxide and copper oxychloride for use on vines and fruit. These products offer traditional, broad-spectrum, low-cost disease control and return steady sales year-on-year. Many copper salts have received EU Annex 1 approval. In 2012 Arysta and DuPont’s Pakistan subsidiaries entered into an agreement to develop the copper hydroxide product Kocide. In 2014 DuPont divested its global Kocide operations to Mitsui & Co, with subsidiary Certis acting as distributor in the USA. Makhteshim (now Adama) received US approval in 2012 for the copper sulphate pentahydrate-based MasterCop for use on fruit and vegetables, field crops and grapevines. In 2013 Syngenta gained exclusive distribution rights for Isagro’s Badge WG, a patented formulation of copper oxychloride and copper hydroxide, in a number of European countries. In 2016 Nufarm received approval in Australia for Amicus Blue (amisulbrom and tribasic copper sulphate) for use on brassicas and grapevines. | | | | | |

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| **Cumyluron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Marubeni (Gamyla) | Ishihara | | |
| **Application** | Timing: | Pre- or Post-emergence | **Rate – (g/ha):** 1200 – 2400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grass and Broad leaved weeds | | |
| **Main Mixture Partners :**  bensulfuron-methyl, pentoxazone | | | | | |
| **Recent History:**  Dibenzylurea herbicide active via a suppression of cell division. Originally discovered by Nippon Carlit but taken to the market by Marubeni for use in both direct seeded and transplanted rice. In 2011 Ishihara gained registration in Japan for two mixture products, with bensulfuron-methyl and pentoxazone, as part of its Dohji-guard range. | | | | | |

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| **Cyanazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | <10 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Bladex) | Chinese Companies | | |
| **Application** | Timing: | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 670-6700 |
| **Main Crops** | **Main Pests** | | |
| F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** atrazine | | | | | |
| **Recent History:**  One of the less persistent triazine herbicides, cyanazine has found uses as a replacement for atrazine. However, following a special review by the US EPA due to groundwater concerns, DuPont phased out the product. Whilst other companies took up the marketing of the product, all usage in the USA was phased out by 2003. In 2002 BASF sold its former Cyanamid cyanazine business in the EU to Feinchemie Schwebda, now Adama, however the product was not accepted for Annex 1 registration and left the EU market in July 2003. The main market for the product is now in Japan. | | | | | |

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| **Cyantraniliprole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 80 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Lumiderm, Benevia) |  | | |
| **Application** | **Timing:** | Foliar, Soil, Seed treatment | **Rate – (g/ha):** 10-100 |
| **Crops** | **Main Pests** | | |
| Rape, F&V, Pome fruit | Sucking and chewing pests, including Lepidoptera, Coleoptera, Diptera, Thysanoptera and Homoptera. | | |
| **Main Mixture Partners:** thiamethoxam | | | | | |
| **Recent History:**  Also known as Cyazypyr®. Developed as DPX-HGW86 by DuPont, the product acts by binding to the ryanodine receptor, similar to chlorantraniliprole and flubendiamide. DuPont sees the product as being complementary to its first anthranilic diamide product, chlorantraniliprole. Syngenta and DuPont have entered into an agreement to share the costs of registrations, with each company to commercialise the product. The first approval was received by DuPont in Argentina in 2012 as Benevia for use on tomatoes. DuPont then received Canadian approval for Benevia in 2013 for use on potatoes. Verimark, an in-furrow and seed treatment product for potatoes and a soil applied product for brassica vegetables; Exirel, for use on fruit and vegetables; and Lumiderm, a seed treatment for canola, have also been introduced. DuPont also launched the product in China in 2013 for use on onions and Chinese cabbages. Recent introductions by Syngenta include the seed treatment Fortenza Duo (with thiamethoxam) in Argentina for use on maize, soybeans and sunflowers in 2013; Fortenza in the USA in 2013; Zyrox, a fly granular bait, in the USA in 2014; Ference, for use on turf in the USA in 2014; and Fuliang (cyantraniliprole and thiamethoxam) in China in 2015. In 2016 Syngenta received US EPA approval for Mainspring GNL. Also in 2016, DuPont’s Okina was approved for use in Canada for use on greenhouse crops, and Benevia was approved for use in Brazil to control coffee borers. In 2017 FMC acquired DuPont’s global chewing pest insecticide portfolio including cyantraniliprole. | | | | | |

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| **Cyazofamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 90 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Ranman, Mildicut) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 60-100 |
| **Main Crops** | **Main Pests** | | |
| Potato | Potato blight, Late blight | | |
| Vine, F&V | Oomycete diseases, Downy mildew | | |
| **Main Mixture Partners :** polyoxins | | | | | |
| **Recent History:**  Oomycete fungicide manufactured by Ishihara but licensed out to many different companies. The product is marketed by BASF in markets outside Asia. Introduced in 2001 in the UK and France for potato blight control and in Japan for vine, potato, cucumber, melon and tomato. Positioned in a very competitive sector with many new introductions. Launched in Mexico in 2005, as Ranman in USA and Brazil in 2006 and in Canada in 2007 by FMC. FMC has a distribution agreement with ISK for the product throughout the Americas excluding Argentina, Bolivia, Uruguay and Paraguay. Launched in Finland, Estonia, Latvia and Lithuania in 2005 by Swedish company Nordisk Alkali for use on potatoes. During 2011 Ishihara registered the product in Japan in a mixture with polyoxins as Greenwork. Belchim introduced the product as Ranman Top in Italy in 2012 whilst ISK received approval in Canada for use of the product as Torrent for potatoes, cucurbits and carrots. In 2014 Summit Agro introduced Ranman 400 in the USA for use on a range of fruit and vegetable crops. The EU has granted an extension to the current approval for the product until the end of July 2018. In 2015 Ranman was approved for use in Australia and New Zealand. | | | | | |

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| **Cyclanilide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <10 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Finish) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cotton |  | | |
| **Main Mixture Partners :** ethephon, mepiquat chloride | | | | | |
| **Recent History:**  Cotton defoliant and boll opener used as a harvest aid to produce a uniform crop. The leaf drop prevents staining of the lint at harvest, whilst consistent boll opening allows single pass harvesting of the crop. Stance, a mixture with mepiquat chloride, was launched by Bayer in the USA in 2006 for use as a growth regulator. The product has been phased out in the EU. | | | | | |

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| **Cyclaniliprole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other - Diamide | - | 2017 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Potato, Tea, Nuts, Soybean, Cotton | Lepidopteran, Coleopteran, Thysanopteran, Dipteran, and Homopteran insect pests | | |
| **Recent History:**  Ryanodine receptor modulator insecticide. Under development for use in major markets worldwide. Decision is pending for approval in Canada and Japan. In 2017, the company withdrew its application for registration in the EU. Registration has been achieved in South Korea, with sales commencing in early 2017 in that region. Registrations have also been achieved in the US and Australia with launched expected to follow shortly in those countries. | | | | | |

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| **Cycloprothrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Kayaku (Cyclosal) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Stinkbug, Water weevil. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum pyrethroid-type insecticide developed for use in rice. Primary activity is against rice water weevil. One of the few pyrethroids used in the paddy rice sector due to aquatic toxicity concerns with many of the others. | | | | | |

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| **Cyclosulfamuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Invest, Nebiros) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 25-60 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** cafenstrole, daimuron, benzobicyclon, pentoxazone | | | | | |
| **Recent History:**  Broad-spectrum sulfonylurea herbicide with a long duration of activity against broadleaved weeds, some grasses and some sedges. Major usage is in Japan in the ‘one-shot’ product Nebiros with cafenstrole and daimuron. The product has now been introduced throughout East Asia and also achieves some sales in Latin America. | | | | | |

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| **Cycloxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | 40 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Focus, Stratos) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 100-400 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Rape, Sunflower, Rice, Vine | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Graminicide for annual and perennial weed control in a range of broadleaf crops. BASF and RAGT have multiple varieties of maize naturally resistant to cycloxydim, known as Lexxor, for the French market. Has received EU Annex 1 approval. | | | | | |

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| **Cyenopyrafen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan (Starmite) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 150-300 |
| **Main Crops** | **Main Pests** | | |
| F&V, Ornamentals, Pome fruit | Mites (Two spotted spider mite, European red mite, Citrus red mite) | | |
| **Main Mixture Partners:** pyridaben | | | | | |
| **Recent History:**  Pyrazole acaricide with new mode of action, developed as NC 512. Registration has been achieved in Japan (2008) and Korea, and is also being progressed in the USA by Nissan and the Canyon Group, a joint venture with Gowan. Introduced in Ecuador and Colombia for use on ornamentals. A mixture with pyridaben has been introduced in Japan as Value Star. | | | | | |

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| **Cyflufenamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Pancho) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 25 ppm |
| **Main Crops** | **Main Pests** | | |
| Cereals, Vine | Powdery mildew and Brown rot | | |
| **Main Mixture Partners :** triflumizole, difenoconazole | | | | | |
| **Recent History:**  First introduced in Japan in 2003, a mixture with triflumizole was also developed to counteract the possibility of early resistance development. The company claims no cross-resistance with other powdery mildew control products on cereals. Certis launched the product in the UK in 2005 but with limited availability. The product has since been introduced in several other countries including Austria, Belgium, Bulgaria, Germany and Romania. In 2008 Nippon Soda entered into an agreement with Syngenta to expand the use of the product to vines, top fruit and vegetables in Europe. In 2013 Syngenta launched Dynali, a combination with difenoconazole, in Portugal for powdery mildew control and black rot on vines. In 2012 Nippon Soda gained US approval of the product as Miltrex 10 for use on fruits and ornamentals and as Cyflufenamid 10 for outdoor ornamentals. Nippon Soda received Australian approval for the product as Cyflamid for powdery mildew control on cucurbits and vines in 2013. Has achieved Annex 1 approval in the EU. | | | | | |

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| **Cyflumetofen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Danisaraba) |  | | |
| **Application** | Timing: | Pre-harvest, beginning of outbreak | **Rate – (g/ha):** 50-200 |
| **Main Crops** | **Main Pests** | | |
| F&V | Mites (*Tetranychus*, *Panonychus*) | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Activity is claimed against egg, larval and adult stages. The first registrations for the product were received in Japan in late 2007. Certis launched the product as Scelta in the Netherlands in 2012 for use on ornamentals. Received approval from Anvisa in Brazil in 2013. Has also achieved EU Annex 1 approval. BASF markets the product in North America as Nealta for speciality crops and as Sultan for turf and ornamentals. Nealta gained approval for use in California during 2016 for use on tree nuts, grapevines, strawberries, tomatoes, citrus and pome fruit. | | | | | |

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| **Cyfluthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 150 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Baythroid) | Adama, Amvac | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Soybean | Armyworm, Cutworm, Thrips, Corn Rootworm, Corn Borer | | |
| Cotton | Bollworm complex, Boll weevil, other Lepidoptera, Thrips. | | |
| Maize | Corn Rootworm, Cutworm, Cornstalk Borer, Wireworm | | |
| Plantation crops, F&V, Cereals | A wide range of insects | | |
| **Main Mixture Partners :** oxydemeton-methyl, tebupirimfos, imidacloprid | | | | | |
| **Recent History:**  Broad-spectrum pyrethroid insecticide, now primarily sold in the resolved form beta-cyfluthrin (Bulldock). Registered for use on a wide range of crops, and also finds usage in the public and animal health markets. Although sales declined in the early 2000s, the product has more recently enjoyed further growth, particularly in the soybean insect control sector. Adama has acquired the European rights to the product from Bayer. Further non-crop registrations were received by Bayer for termite control in the USA in 2004 as Tempo Ultra, and by Gustafson as Storcide, a product for stored grain. In 2010 Amvac acquired Aztec (cyfluthrin and tebupirimifos) from Bayer, which is marketed as Capinda in South Korea. Aztec is registered in the USA and Mexico for use on maize whilst Capinda is used on vegetables. In 2012 Bayer launched beta-cyfluthrin in a mixture with imidacloprid in Argentina as Solomon for use on soybeans. Refused re-registration in the EU, with the resolved form beta-cyfluthrin approved until the end of October 2018. | | | | | |

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| **Cyhalofop-butyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 165 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Clincher) |  | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 50-100 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** pendimethalin, quinclorac, clomazone | | | | | |
| **Recent History:**  Graminicide that has been well accepted in Japan for the provision of the grass weed control element in ‘one-shot’ rice herbicides, notably Hokuto and Joystar, and also finds usage in solo formulations in Latin America and the USA. The product has reduced risk status in the US and full registration was received in 2002. Cyhalofop has a wide window of application and is particularly active against sprangle top and early watergrass and is recommended for tank mixing with pendimethalin, quinclorac and clomazone. Received approval as Barnstorm in Australia in 2005 for use on barnyard grass and silver top on rice. Has received registration in the EU with approval extended to the end of June 2032. | | | | | |

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| **Cyhexatin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Plictran, Pennstyl) | Sipcam-Oxon, Chemia | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V, Pome fruit | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  At one time a leading miticide active against larvae and adults marketed by Dow, however this position was eroded through regulatory action. Now part of the UPL portfolio following the acquisition of Cerexagri, UPL subsequently acquired related tin-based products from DuPont to enhance their portfolio in the sector. Has been refused re-registration in the EU and all tolerances were cancelled in the USA in 2005. The product has also been refused re-registration in Brazil, with all uses prohibited from October 2011; however Anvisa temporarily lifted the ban following a challenge by Sipcam-Oxon. | | | | | |

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| **Cymoxanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 120 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Curzate) | Oxon | | |
| **Application** | Timing: | Foliar, Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Potato | Early blight, Potato blight | | |
| F&V | A range of diseases | | |
| Vine | Downy mildew, Excoriosis | | |
| **Main Mixture Partners :**  mancozeb, dithianon, metiram, famoxadone, maneb, triadimenol, propineb, triadimefon, fosetyl-al, folpet, copper-oxychloride, trifloxystrobin, chlorothalonil, azoxystrobin, copper-sulphate, benthiavalicarb, isopropyl, propamocarb | | | | | |
| **Recent History:**  One of the leading products for the treatment of downy mildew on vines and blight on potatoes. Cymoxanil has relatively short persistence and as a result is used in many mixtures to extend its period of action. The product also maintains an important position in the fruit and vegetable markets. Has achieved re-registration in the EU, however many newer entrants are making the sector much more competitive. In 2010 Nippon Soda gained Japanese registration for the product in a mixture with benthiavalicarb and isopropyl as Betofighter. In 2012 DuPont reached agreement for Arysta’s Pakistan subsidiary to distribute Curzate in the country for use on high value crops, including potatoes. Belchim has launched the product in a mixture with propamocarb hydrochloride in Italy as Axidor. | | | | | |

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| **Cypermethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 310 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Mustang) | Syngenta, Sumitomo, BASF, Bilag, Dow, Gharda, Meghmani, Atul, Coromandel, Tagros, UPL, Atanor, Sinon, Bharat Rasayan, Heranba, Nortox | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 30-110 |
| **Main Crops** | **Main Pests** | | |
| Maize, Soybean | Native budworm, Corn earworm | | |
| Cotton | Bollworm complex, Boll weevil, Other Lepidoptera, Thrips | | |
| F&V, Cereals, Rice | A wide range of insects | | |
| **Main Mixture Partners :**  thiamethoxam, chlorpyrifos, quinalphos, monocrotophos, piperonyl-butoxide, methomyl, flufenoxuron, ipconazole | | | | | |
| **Recent History:**  Commodity broad-spectrum pyrethroid insecticide manufactured by many companies and used in a wide range of applications. The product offers low-cost pest control and maintains a strong position in the pyrethroids market. However, sales are down from peak levels due to several factors: loss of market share to resolved pyrethroids; increase in *B.t.* crops; and recent insecticide introductions offering novel modes of action. In 2006 the US EPA agreed to re-register all uses, providing certain measures are taken to reduce risks. Has received full Annex 1 re-registration in the EU. In 2010 approval was granted in Spain for the product on stink bugs in rice. Chemtura (now Arysta LifeScience) received Australian approval for its Rancona C seed treatment, also containing ipconazole, in 2010. In 2012 Chemtura’s seed treatment Signal was approved in the UK for use on cereals. In 2012 Certis Europe introduced the product as Belem in Italy for use on a range of crops including maize, sweetcorn, sorghum and sunflower. Currently under review for continued use in Canada. The resolved forms alpha-cypermethrin, beta-cypermethrin and zeta-cypermethrin are also commonly used. Beta-cypermethrin has not been re-registered in the EU. | | | | | |

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| **Cyproconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Triazole | 450 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Alto) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 10-100 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Asian rust | | |
| Cereals | Brown rust, Leaf blotch, Septoria leaf spot, Yellow rust | | |
| Maize, F&V | A range of diseases | | |
| **Main Mixture Partners :** trifloxystrobin, azoxystrobin, propiconazole, carbendazim, prochloraz, thiamethoxam, picoxystrobin | | | | | |
| **Recent History:**  Following introduction by Sandoz, cyproconazole quickly became one of the leaders in the cereal fungicide market. Since its introduction, usage has been expanded into many mixture formulations for use on a broad range of crops. Bayer acquired the marketing rights for solo formulations of cyproconazole in Europe, with Syngenta retaining the mixture formulations. The product has received EU registration. The main market is now on soybeans for the control of Asian rust, primarily in Brazil in a mixture with azoxystrobin. In 2011 DuPont was granted a use extension for the product in a mixture with picoxystrobin as Aproach Prima for use on wheat, maize, rice, sugarcane, cotton and coffee in Brazil. This was followed in 2013 with US approval for Aproach Prima for use on soybeans, maize and wheat. Currently under registration review for use in the USA. | | | | | |

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| **Cyprodinil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Anilinopyrimidine | 190 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Unix) | None | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals | Eyespot, Powdery mildew | | |
| F&V, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** fludioxonil, propiconazole, difenoconazole, isopyrazam, azoxystrobin | | | | | |
| **Recent History:**  Broad-spectrum anilinopyrimidine fungicide active via inhibition of methionine biosynthesis. Active against powdery mildew and most species and strains of eyespot in cereals, as well as *Rhynchosporium* and Net blotch on barley. It is also used to control a broad range of fruit and vegetable diseases, including *Botrytis*. Also used in a number of mixture formulations, including with fludioxonil as Switch for use on vines; with isopyrazam as Bontima for use on barley; and with difenoconazole for use on pome fruit and grapes. Syngenta introduced Kayak in the UK in 2006, a liquid formulation with a reported 25% improvement in activity against *Rhynchosporium*. Has received re-registration in the EU. | | | | | |

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| **Cyromazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other – IGR | <30 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Trigard) | None | | |
| **Application** | Timing: | Foliar, Soil | **Rate – (g/ha):** 75-225 |
| **Main Crops** | **Main Pests** | | |
| F&V, Potato | Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  A systemic triazine insect growth regulator active via disruption of moulting and pupation. One of the first insect growth regulators to be commercialised, the major usage being on speciality crops. Cyromazine has now largely been superseded and sales are mature. Also finds applications in animal health. Has received Annex 1 approval in the EU. In 2017 Adama took over Syngenta’s cyromazine based products including Trigard and Armor. | | | | | |

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| **Daimuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | <10 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| SDS Biotech (Showrone) | None | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 45-2000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :**  pyraclonil, bromobutide, bensulfuron, cafenstrole, pyrazoxyfen, benzobicyclon | | | | | |
| **Recent History:**  Urea herbicide, a speciality product for sedge control that is used in a number of ’one-shot’ rice herbicides, initially in Zark G and then in a number of ‘Jumbo’ formulations, such as Kusatory Ace Jumbo. In 2009 Nihon Nohyaku launched the product in a range of new herbicides in mixtures with pyraclonil, bromobutide and bensulfuron methyl under the Ippon D brand. In 2011 Ishihara received registration in Japan as a mixture with cafenstrole, pyrazoxyfen and benzobicyclon as Tobikiri. | | | | | |

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| **Dazomet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 40 | 1942 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Basamid) | UCB | | |
| **Application** | Timing: | Soil applied,  Fumigant | **Rate – (g/ha):** 200000-600000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops, Turf, Ornamentals, Potato | Nematodes, Insects, Diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pre-plant incorporated soil fumigant for broad-spectrum control of nematodes, weed seeds and soil fungi, a precursor of methyl isothiocyanate. Unlike other soil fumigants, dazomet is applied as a dry granule and incorporated into the soil or applied to the soil surface. BASF was the major manufacturer of the product, and Agro-Kanesho the distributor in Japan, however in 2004 BASF divested all of its soil fumigants business to Agro-Kanesho. In 2010 Amvac acquired exclusive distribution rights for the product in the USA from Kanesho Soil Treatment, a joint venture between Agro-Kanesho and Mitsui Chemicals. Re-registered in the EU. | | | | | |

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| **Deltamethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 325 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Decis) | Gharda, Tagros, Adama, Sinon, Heranba, Bharat Rasayan, Meghmani | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 2-30 |
| **Main Crops** | **Main Pests** | | |
| Cotton | Boll weevil, Bollworm, Other Lepidoptera, Thrips. | | |
| F&V, Rape, Cereals, Rice, Potato, Maize | A wide range of insects | | |
| **Main Mixture Partners :** endosulfan, heptenophos, chlorpyrifos-methyl, pirimicarb | | | | | |
| **Recent History:**  The first resolved pyrethroid to reach the market, now subject to significant generic competition. Originally a Roussel product that passed to Aventis and now part of Bayer, who chose to retain the product in preference to the proprietary beta-cyfluthrin. In 2006 Arysta received a licence from Bayer to sell the product in US crop markets. Introduced as a new emulsion in water formulation, Decis Protech, in Spain in 2009 for use on vegetables. Significant sales are also achieved in non-crop markets, including as K-Othine Pronto Uso for the control of ants, cockroaches and mites in Brazil and as Suspend Polyzone in the USA. In addition, Bayer has introduced LifeNet mosquito nets, with the product incorporated into polypropylene fibres, in 2012 in Malawi, Namibia and Zambia. In 2013 Bayer and the Innovative Vector Control Consortium launched an indoor residual spray for malaria vector control in Sub-Saharan African markets. Bayer’s Decis Evo was granted use extension for use in Italy in 2016. Also in 2016 the active ingredient gained approval extension in the EU, with use currently permitted until the end of July 2017. | | | | | |

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| **Demeton-S-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | <10 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Metasystox 1) | Chinese companies | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 100-400 |
| **Main Crops** | **Main Pests** | | |
| Rice, Plantation crops, F&V | Broad range of insects, Mites, Aphid, Leaf miner | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Mature commodity organophosphorous insecticide now of limited commercial significance. Not registered for use in the USA, withdrawn from the Australian market in 1998 and not re-registered in the EU. | | | | | |

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| **Desmedipham** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | 40 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Betanal AM) | UPL | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 940 |
| **Main Crops** | **Main Pests** | | |
| Sugarbeet, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** ethofumesate, phenmedipham | | | | | |
| **Recent History:**  Mature carbamate herbicide used predominantly in mixtures on sugarbeet, notably with phenmedipham and ethofumesate, also finds some minor usage in soft fruit. Re-registration in the EU has been achieved until July 2018. | | | | | |

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| **Diafenthiuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 90 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Polo, Pegasus) | Meghmani | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-400 |
| **Main Crops** | **Main Pests** | | |
| Cotton | Whitefly, Thrips, Aphids | | |
| F&V, Ornamentals | Aphid, Mites, Whitefly, Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Thiourea acaricide with insecticidal activity for the control of sucking pests and mites in cotton, fruit, vegetables and ornamentals. Key markets are on cotton in Brazil and Pakistan. Now subject to some generic competition, and also competition from more recently introduced sucking pest insecticides, although the product benefits from miticidal activity which most of these do not possess. Has not been re-registered in the EU. In 2012, in collaboration with Syngenta, Jiangsu Changqing opened a new manufacturing facility in China for the product. Gained registration in Brazil as Polo in 2016 for the control of whiteflies on soybean. | | | | | |

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| **Diazinon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | 60 | 1954 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Diazol, Basudin) | Nippon Kayaku, Sudarshan, Chinese Companies | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 300-4500 |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops, Pome fruit | A wide range of insects/mites and nematodes | | |
| Maize | Corn rootworm. European Corn borer, Flea beetle, Grasshoppers, Armyworm, Wireworms, Mites, Aphid | | |
| Potato | Colorado beetles, Nematodes, Aphid, Leaf hoppers | | |
| **Main Mixture Partners :** phorate | | | | | |
| **Recent History:**  Broad-spectrum commodity organophosphorus insecticide with a wide range of crop and non-crop applications. In 2006 a number of US crop labels were withdrawn by the registrants to meet re-registration requirements. Syngenta cancelled its US approvals in 2004; Adama retained some agricultural uses. Re-registration in the EU was refused in 2007. Usages in Canada and New Zealand have been phased out. The trade and use of diazinon has been banned in India from 1st January 2018. | | | | | |

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| **Dicamba** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | 270 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Banvel) | Syngenta, Gharda, Chimiberg, Rotam, Arysta LifeScience | | |
| **Application** | Timing: | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 150-9000 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize, Soybean | Broadleaved weeds | | |
| **Main Mixture Partners :**  metsulfuron-methyl, triasulfuron, mesotrione, rimsulfuron, bromoxynil, 2,4-D, bentazone, atrazine, s-metolachlor, nicosulfuron, diflufenzopyr, tritosulfuron, MCPA, chlorsulfuron | | | | | |
| **Recent History:**  Provides early season control of broadleaf weeds on maize and cereals, a sector where it has very little direct competition. BASF markets the product for crop use in the USA, with Syngenta marketing the product in the rest of the world. Sales on maize have been impacted by the uptake of herbicide tolerant varieties in the USA, with the main market for the product now being cereals. In 2009 BASF and Monsanto entered into a joint licensing agreement to develop dicamba formulations to be used in herbicide-resistant cropping systems. In 2012 Monsanto introduced its Roundup Ready Xtend soybean system, which features dicamba and glyphosate tolerance. In conjunction with this, BASF will market Engenia, an advanced formulation for use on dicamba-tolerant crops, whilst Monsanto will market Xtend. BASF has expanded production capacity for dicamba at its Beaumont, Texas site, whilst Monsanto has upgraded its Luling, LA, facility in support of the company’s Roundup Ready Xtend system. In 2015 Bayer received registration for DiFlexx in the USA for use on corn and in 2016 launched DiFlexx Duo, a mixture with tembotrione. In 2016 Monsanto and DuPont entered into a multi-year supply agreement in the USA and Canada regarding the herbicide with DuPont to market FeXapan herbicide plus VaporGrip Technology for use on Roundup Ready 2 Xtend soybeans. | | | | | |

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| **Dichlobenil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other - Hydroxybenzonitrile | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Casoron) | None | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V, Pome fruit, Vine | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Herbicide for broad-spectrum weed control in orchards, vines, non-crop, aquatic and horticultural situations. A niche product of limited commercial significance. Marketed by Agro-Kanesho in Japan. Not re-registered in the EU, with approval withdrawn in 2009. | | | | | |

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| **Dichloropropene** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 140 | 1942 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Telone) | Agro-Kanesho | | |
| **Application** | Timing: | Soil applied | **Rate – (g/ha):** 200000-400000 |
| **Main Crops** | **Main Pests** | | |
| Potato | Nematodes | | |
| F&V, Tobacco, Peanuts, Vine | A wide range of insects and diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  One of the leading soil fumigants, particularly in Japan. The product stands to gain from the regulatory action against methyl bromide. BASF also had a position with the product; however this was divested to Agro-Kanesho in 2004. Has not been re-registered in the EU. | | | | | |

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| **Dichlorprop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Phenoxy | <10 | 1961 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nufarm (Duplosan) | UPL | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 2700 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** bentazone, cinidon-ethyl, tribenuron-methyl, MCPA, MCPP-P | | | | | |
| **Recent History:**  Phenoxy herbicide mainly used in cereals for post-emergence control of broadleaved weeds, now largely replaced by the resolved form dichlorprop-p, which is sold as Duplosan DP and Optica DP by Nufarm. BASF divested its phenoxy herbicides operations, including Duplosan, to Nufarm in 2004. Dichlorprop has not been re-registered in the EU, although dichlorprop-p has been approved. | | | | | |

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| **Dichlorvos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | 75 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Nuvan) | Adama, Jin Hung Fine Chemical, FMC, UPL, FarmHannong, Meghmani | | |
| **Application** | Timing: | Foliar, Fumigant | **Rate – (g/ha):** 200-2000 |
| **Main Crops** | **Main Pests** | | |
| Rice, Cotton, F&V, Maize | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity insecticide which benefits from rapid knock-down activity and usage in many sectors including crop, post-harvest, public health, household and animal health (both in animal housing and as an anthelminthic). Notified for re-registration in the US, but subject to certain use restrictions. In 2006 Amvac requested that the EPA cancel usages on mushroom houses, greenhouses, and turf & ornamental treatments. Registration in the EU was refused in 2007, with the product phased out of the market by 2012. In 2008 Australian authorities banned usage on potatoes, mushrooms and food crops grown in glasshouses, as well as post-harvest use on legumes. Cheminova (now part of FMC) phased out the product in India as part of its bid to discontinue its WHO Class I products. A phase out of dichlorovos in India will culminate in its complete ban by the end of 2020. | | | | | |

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| **Diclocymet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other amide | <10 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Delaus) | None | | |
| **Application** | Timing: | Seedling box | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Blast | | |
| **Main Mixture Partners :** clothianidin, fipronil | | | | | |
| **Recent History:**  Rice Blast fungicide developed by Sumitomo as S2900 and introduced in Japan in 2000 as Delaus. The product has been introduced as a 3% granule formulation, with an application rate of 50g per seedling box. Introduced in 2002 in a mixture granule formulation for nursery box application with Takeda’s clothianidin. | | | | | |

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| **Diclofop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Diphenyl Ether | <30 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Colt, Hoelon) |  | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 700-1300 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses | | |
| **Main Mixture Partners :** fenoxaprop-P-methyl, sethoxydim | | | | | |
| **Recent History:**  At one time the leading graminicide for use on cereals, but now superseded by more recent introductions and sales are considerably below peak levels. The product has found usage in more niche markets and has gained re-registration in the EU. Registrations in the USA have been cancelled on a voluntary basis by Bayer, with effect from Jan 1st 2018. | | | | | |

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| **Diclomezine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Monguard) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-500 |
| **Main Crops** | **Main Pests** | | |
| Rice | Seedling blight, Sheath blight | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Developed for the control of blight in rice and predominantly used in the Japanese market. Now of minor commercial significance. | | | | | |

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| **Diclosulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Other | 135 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Spider, Coact) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 31 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Peanut, Sugarcane | Broadleaved weeds | | |
| **Main Mixture Partners :** glyphosate, halauxifen | | | | | |
| **Recent History:**  Marketed in the Americas for use on soybeans (Spider) and peanuts (Strongarm), the first soil applied herbicide for use on the crop. Initially sales were slow to take off, principally due to competition from glyphosate on Roundup Ready varieties. However, the product was subsequently well received, particularly in Argentina and Brazil where it is also sold in a mixture with glyphosate as Spider Ultra. Sales have been impacted by the introduction of Roundup Ready soybeans, although the product remains one of the leading soybean herbicides in many important country markets. Dow launched Strongarm in India for use on soybeans in 2015. | | | | | |

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| **Dicofol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organochlorine | <30 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Mitigan, Acarin) | Hindustan Insecticides, Gowan | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 400-3000 |
| **Main Crops** | **Main Pests** | | |
| Cotton | Bollworm complex, Mites | | |
| F&V, Plantation crops, Maize | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum miticide with only limited insecticidal activity. The product is now mature and was discontinued by Dow in 2007. In 2011 Adama commenced a phase-out of the product, with the company requesting all registrations and approvals be removed. The company halted production and the EPA cancelled all remaining registrations in December 2011, with usage allowed until the end of October 2013. Distribution and sale by other companies was allowed until the end of 2013, with use of remaining stocks now permitted until the end of October 2016. Not re-registered in the EU. | | | | | |

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| **Dicrotophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | <30 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Bidrin) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 300-1000 |
| **Main Crops** | **Main Pests** | | |
| Cotton, Plantation crops | A wide range of insects/mites. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorus insecticide/acaricide widely used on plantation crops with a range of applications in other crop sectors, also with outlets in animal health. Mainly used by tree injection on cotton in the USA. Has not been re-registered in the EU. | | | | | |

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| **Diethofencarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Powmyl) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-4600 |
| **Main Crops** | **Main Pests** | | |
| F&V | A range of diseases | | |
| Vine | Botrytis | | |
| **Main Mixture Partners :** benomyl, thiophanate, carbendazim | | | | | |
| **Recent History:**  A specific Botryticide for use on vines, fruit and vegetable crops, with secondary activity against powdery mildew (*Cercospora* and *Venturia*). Predominantly used in mixtures to expand its spectrum of activity. The product has gained EU approval. In 2012 Sumitomo Chemical received registration for Powmyl for use on bananas in the Philippines and introduced a mixture with benomyl for use on beans in Japan. Currently under review for use in the USA. | | | | | |

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| **Difenoconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 290 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Score, Dragon, Dividend) | Atul, Meghmani, Chinese Companies | | |
| **Application** | Timing: | Foliar,  Seed treatment | **Rate – (g/ha):** 75-125 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cereals, Plantation crops, Rice, Pome fruit, Cotton, Rape | A wide range of diseases | | |
| **Main Mixture Partners :**  propiconazole, fenpropidin, iminoctadine, metalaxyl, mandipropamid, cyprodinil, thiamethoxam, sedaxane, fludioxonil, benzovindiflupyr | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide, now subject to generic competition. The first generic version was introduced for use on cereals in Brazil by Helm. Syngenta has introduced a number of mixture products, including with mandipropamid as Revus Top in Canada and Amphore Plus in the UK; and with cyprodinil as Inspire Super for use on pome fruit and vines in the USA. Also finds significant usage in seed treatment products, primarily as a component of Syngenta’s Cruiser Maxx range (difenoconazole, fludioxonil and thiamethoxam). Has also been introduced in a range of seed treatments with sedaxane, with mixtures integrating fludioxonil, metalaxyl-m and/or thiamethoxam in different formulations. In 2015 Syngenta received approval in Canada for Aprovia Top, a mixture with benzovindiflupyr for use on fruiting vegetables and cucurbits, and in 2016 for Inspire and Visivio (sulfoxaflor, difenoconazole, metalaxyl-M, fludioxonil and sedaxane). EU re-registration has been achieved. In 2017 Syngenta launched Revus Top (mandipropamid and difenoconazole) in Argentina for blight control on potatoes. | | | | | |

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| **Difenzoquat** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Avenge) | Chinese companies | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 500-1500 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Specific herbicide for post-emergence wild oat control in cereals. Now largely superseded by new introductions and not re-registered in the EU. Acquired by Amvac from BASF in 2006. The US EPA cancelled all registrations of the product in 2010 at the request of Amvac. Main markets for the product are now China and Canada. | | | | | |

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| **Diflovidazin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Chemie (Flumite 200) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 80-120 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, F&V | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Acaricide from Chinoin, now Agro-Chemie, an analogue of clofentezine claiming good activity against egg and chrysalis stages of mite development. Formerly known as flufenzine. Introduced in 1997 in Hungary, followed by a number of other eastern European markets. Also marketed in Asia and South America. Has been refused re-registration in the EU. | | | | | |

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| **Diflubenzuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 60 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Dimilin) | Chinese companies | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 70-140 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Maize, Pome fruit | A wide range of insects. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  The first benzoylurea to be commercialised and still a significant product in that sector. Has applications in many crop and non-crop situations, although sales are now well below peak levels. Used for locust control in eastern Europe, and grasshopper and cricket control in the USA. A termite control baiting system was introduced in the USA in 2003 by Whitmore Micro Gen, utilising diflubenzuron as the active ingredient. Also has some applications in animal health. EU re-registration has been achieved. In 2008 Certis Europe launched the selective insect growth regulator Indipendant for use on pome fruit, ornamentals, nursery stock and forestry. Granted an exceptional use authorisation in Spain in 2010 for vector control on rice. Arysta also distribute the product as Dimilin in Africa for mosquito control. Introduced in the USA in 2013 as DoubleTake, which also contains lambda-cyhalothrin, for use on cotton, peanut, soybeans and peppers. Following Chemtura’s acquisition by Platform Speciality products, the product is now marketed under the Arysta LifeScience trade name. Helm’s Diflumax 2L gained approval for use in the USA for use on various crops in 2016. | | | | | |

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| **Diflufenican** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 130 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Brodal) | Adama, Punjab Chemicals, Chinese Companies | | |
| **Application** | Timing: | Pre-emergence,  Post-emergence | **Rate – (g/ha):** 1250-2250 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** flurtamone, isoproturon, bromoxynil, ioxynil, chlorotoluron, flufenacet, glyphosate | | | | | |
| **Recent History:**  Broadleaf weed herbicide which is used mostly in combination with isoproturon to broaden its spectrum of weed control on cereals. The product has suffered from regulatory action against isoproturon due to groundwater concerns, as well as resistance issues. EU re-registration has been achieved, with the major markets for the product being Germany, France and the UK. In 2006 Bayer entered into supply agreements with Nufarm and Cheminova (now part of FMC), resulting in these companies gaining access into European markets with a number of diflufenican formulations, as well as developing their own range of formulations. In 2010 Bayer launched the product in a mixture with flufenacet and flurtamone as Bacara Forte for use on cereals in Chile. In 2013 Rotam CropSciences received registration in Argentina for Tuken to control broadleaf weeds in a range of crops including sunflowers and pasture. Bayer gained Japanese approval for Liberator G (diflufenican and flufenacet) for use on cereals in 2014. In 2015 Blutron and Blutron Plus, both containing isoproturon and diflufenican, had approval for use in the UK expanded for use in autumn, expanding its current spring application approval. | | | | | |

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| **Diflufenzopyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 60 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Distinct, Status) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Maize | Grass and Broadleaved weeds | | |
| **Main Mixture Partners :** nicosulfuron, dicamba | | | | | |
| **Recent History:**  Semicarbazone herbicide introduced in North America for grass and broadleaved weed control in maize in a mixture with dicamba, which is marketed as Distinct. The product acts through an inhibition of auxin transport and controls triazine resistant weeds, however it has yet to make a significant commercial impact. Introduced for non-crop usage as Overdrive in the USA in 2004, offering control of the difficult weed leafy spurge. Also finds usage in a tank mix with glyphosate on Roundup Ready maize or for stand-alone broadleaf weed control on conventional maize in a mixture with dicamba as Status. | | | | | |

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| **Dikegulac** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <10 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Atrinal) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop |  | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  PGR of minor commercial significance mainly for use in ornamentals to control apical dominance, and to promote branching and bud formation. Not re-registered in the EU. Under registration review in the USA | | | | | |

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| **Dimefluthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical | None | | |
| **Application** | Timing: |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop | Mosquitoes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyrethroid developed for household control of mosquitoes. Introduced in China in 2005. | | | | | |

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| **Dimethachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 35 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Terdox) | None | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 1250-2000 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** clomazone, napropamide | | | | | |
| **Recent History:**  A relatively old chloroacetanilide herbicide that demonstrates good selectivity on oilseed rape. Dimethachlor controls annual grass weeds, including *Alopecurus myosuroides* (black-grass), *Apera spica-venti* and *Poa annua* as well as some broadleaved weeds. Has achieved re-registration in the EU. Used mostly in mixtures, notably with clomazone and napropamide as Colzor Trio in France**.** | | | | | |

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| **Dimethametryn** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | <10 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan |  | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 200-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaf weeds | | |
| **Main Mixture Partners :** cyhalofop, pyrazosulfuron, pretilachlor, esprocarb, oxaziclomefone, benzobicyclon | | | | | |
| **Recent History:**  Ageing triazine herbicide used almost exclusively as a mixture product in one-shot rice herbicides in Japan, initially in Hokuto, with cyhalofop, pyrazosulfuron and pretilachlor, also Sparkstar with pyrazosulfuron, esprocarb and pretilachlor. Nissan acquired the Japanese and Korean rights from Syngenta in 2004. In 2010 Nissan received approval in Japan for SiriusTarbo SC, a mixture with pyrazosulfuron-ethyl, oxaziclomefone and benzobicyclon. | | | | | |

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| **Dimethenamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 165 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Spectrum, Outlook) | None | | |
| **Application** | Timing: | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 750-1500 |
| **Main Crops** | **Main Pests** | | |
| Maize, Rape, Soybean, Cereals, Sunflower | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** pendimethalin, bentazone, terbuthylazine, saflufenacil, imazethapyr | | | | | |
| **Recent History:**  Chloracetamide herbicide, used predominantly in mixtures. Main activity is against grass weeds with some broadleaf weed control. The resolved isomer dimethenamid–P was introduced in the USA in 2001 and France in 2002, with UK approval for use on winter oilseed rape in 2005. Launched as Spectrum in Spain in 2007 for use on maize and as Frontier Max in Canada in 2009 for use on a range of crops including maize and soybeans. Also marketed in the USA for use on turf as Tower. BASF has replaced dimethenamid with products based on the dimethenamid-P isomer, with EU re-registration of the racemic mixture being refused, whilst dimethenamid-P has received EU approval until the end of October 2018. BASF has introduced mixtures with saflufenacil for broadleaf weed control, including as Integrity in Canada for use on maize and as Verdict for soybeans in the USA. In 2012 BASF received US approval for Optill Pro, a mixture containing dimethenamid-P, saflufenacil and imazethapyr for use on soybeans. The company has recently invested over $270 m. to expand production capacity for the herbicides dicamba and dimethenamid at its Beaumont, Texas facility. | | | | | |

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| **Dimethipin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <10 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Chinese Companies | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 300-500 |
| **Main Crops** | **Main Pests** | | |
| Cotton | n.a. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Defoliant with desiccant properties for use on cotton. Registered for use as a cotton herbicide to control sicklepod and morning glory in 1999. A formulation affecting lint maturation, Lintplus, was introduced in 2001. In 2007 Chemtura cancelled all US registrations for the product as Harvade. Not registered for use in the EU following withdrawal from Annex 1 in 2007. The main market for the product is now in China. | | | | | |

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| **Dimethoate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorus | 120 | 1951 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Danadim Expert, Chemathoate) | BASF, Sumitomo, Rallis, IpiCi, Atanor, Gowan, Sinon, Nortox | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 200-1200 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, F&V, Cereals, Rice, Cotton, Potato | A wide range of insects | | |
| **Main Mixture Partners :** chlorpyrifos | | | | | |
| **Recent History:**  Commodity broad-spectrum organophosphorus insecticide with miticidal activity. Still widely used globally, although regulatory action is likely to further limit future performance. Residential, home & garden and farm building uses in the USA have been cancelled, whilst a number of agricultural uses have been voluntarily withdrawn including a number of labels for fruit & vegetables. Has been re-registered in the EU. In 2010 Cheminova acquired Isagro’s global Rogor business, including the rights to the Rogor product name, all registrations and know-how. In 2011 the use of dimethoate was suspended for use in Australia. Passed to FMC following its acquisition of Cheminova. Isagro retained non-exclusive distribution rights for some countries for a 5 year period. | | | | | |

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| **Dimethomorph** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | 80 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Forum, Acrobat) | SePRO (Stature), Chinese Companies | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** 300 |
| **Main Crops** | **Main Pests** | | |
| Potato | Potato blight | | |
| Vine | Downy mildew | | |
| F&V | Downy mildew, various diseases | | |
| **Main Mixture Partners :** mancozeb, folpet, copper-oxychloride, dithianon, ethaboxam, ametoctradin, pyraclostrobin, fluazinam | | | | | |
| **Recent History:**  Morpholine fungicide for the control of downy mildew in vines (Forum) and late blight in potatoes (Acrobat) and introduced in most major fruit and vegetable markets, predominantly in mixtures with contact fungicides. Acquired by BASF as part of Cyanamid. SePRO introduced a mixture with mancozeb for use on ornamentals in the USA as Stature in 2001. Now a very competitive market sector with many new entrants. Re-registration in EU has been accepted with use approved until the end of July 2018. The product has also been introduced by BASF in mixtures with ametoctradin as Zampro: in Chile in 2010 for use on vines, hops, vegetables and potatoes; in the USA in 2012 for speciality crops; in Canada in 2012 for use on fruit and vegetables, hops and vines; and in Australia in 2012 for use on vines. Another ametoctradin mixture, Orvego, has been introduced for use on ornamentals. The same mixture has received approval as Resplend in the UK and in Italy as Enervin Duo for various fruit and vegetable crops. BASF launched the product in a mixture with pyraclostrobin as Cabrio Team in Spain for fruit and vegetables in 2012. In 2014 Adama launched Banjo Forte, a combination with fluazinam for use on potatoes in Europe. Gowan received approval in the UK for Presidium, a mixture with zoxamide, to control potato blight in the region in 2016. | | | | | |

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| **Dimethyl Disulfide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | <10 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arkema (Paladin) |  | | |
| **Application** | Timing: | Pre-planting | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Ornamental, Nursery | Broadleaf weeds, Grasses, various diseases caused by soil borne pathogens e.g. *Verticellum*, *Fusarium, Pythium, Sclerotina* and *Rhizoctonia* species, nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Sulphur-based soil fumigant produced by the French chemical company Arkema (formerly Atofina) which was initially used in industrial applications such as anti-fouling and catalyst activation. Also known as DMDS. In 2010 Arkema gained US approval for the product for use on a variety of fruit and vegetables, forest nursery crops and ornamentals as Paladin. UPL (which acquired the Arkema crop protection subsidiary Cerexagri) partnered with Arkema during the registration process and managed the field trials of the product. Arkema assumed all sales and marketing activities for the product in Mexico and the USA. In 2011 Arkema partnered with Certis for the development, registration and distribution of Paladin in Europe, with the dossier submitted for inclusion on Annex 1 in 2013. The product gained approval as Paladin in Lebanon and as Accolade in Turkey, with UPL to market the products in both countries. Currently under registration review in the USA. | | | | | |

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| **Dimoxystrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 35 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Swing Gold, Pictor) | None | | |
| **Application** | Timing: | Post-emergence | **Rate – (g/ha):** 1500 |
| **Main Crops** | **Main Pests** | | |
| Rape | *Fusarium* ear blight, *Sclerotinia* stem rot, Stem canker, *Alternaria* dark leaf and pod spot | | |
| Cereals | *Fusarium* ear blight, Brown rust, *Septoria tritici*, Tan spot | | |
| **Main Mixture Partners :** epoxiconazole, boscalid | | | | | |
| **Recent History:**  Strobilurin with particular usage for the control of late season *Fusarium* ear blight on cereals, and also used for its greening effect. BASF acquired the rights to develop the product from Shionogi in 1996. Received its first global registration in the UK in 2003 as Swing Gold (a combination with epoxiconazole), a protectant and curative fungicide for use in winter wheat to control late season diseases. Introduced into some markets in 2004, with further registrations in France and Germany in 2006. Granted Annex 1 approval in the EU. Now finds its main usage on oilseed rape. In 2015 BASF launched Pictor (dimoxystrobin and boscalid) for use on oilseed rape. In 2016 BASF also launched Spot SC (a mixture with boscalid) in Brazil for the control of white mould on kidney beans. | | | | | |

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| **Diniconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | <30 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Spotless, Sumi 8) |  | | |
| **Application** | Timing: | Foliar, Soil,  Seed treatment | **Rate – (g/ha):** 50-120 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Pome fruit | Brown rust, Yellow rust, Powdery mildew, Disease, Leaf spot, Rust | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide, active against leaf and ear diseases of cereals, including smuts (*Ustilago* spp.) and bunt (*Tilletia* spp.), applied either as foliar spray or seed treatment. Also used for the control of powdery mildew on vines and apples. Has been refused re-registration in the EU. | | | | | |

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| **Dinocap** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Karathane) | Cequisa | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V | A wide range of diseases | | |
| Vine | Powdery mildew | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Crotonate product used predominantly for the protection of citrus, pome fruit and various vegetable crops from powdery mildew attack, although it does possess some curative activity. Has secondary activity as a non-systemic acaricide against a range of mite species. The related meptyldinocap has now also been introduced. Registration in the EU has been refused. | | | | | |

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| **Dinotefuran** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 105 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Starkle, Alubarin, Venom) |  | | |
| **Application** | Timing: | Foliar,  Seed treatment (nursery box), Soil | **Rate – (g/ha):** 100-200 |
| **Main Crops** | **Main Pests** | | |
| Rice | Water weevils, plant weevils, leafhoppers, planthoppers, aphids, thrips, whitefly and rice bugs | | |
| F&V, Cereals | Broad spectrum | | |  | |
| **Main Mixture Partners :** chlorantraniliprole, tricyclazole, etofenprox | | | | | |
| **Recent History:**  Introduced in Japan 2002 in a 2% granule formulation for nursery box applications and a 20% soluble granule for foliar use. Introduced in Korea in 2003 and the US in 2005 (cotton, vines, vegetables, potatoes and non-crop). The product also has applications in animal health and household pest control. Vectra, a flea treatment for cats and dogs, was introduced in the USA in 2008. Valent achieved registration in the USA as Venom in 2006 for use on vines and in 2007 for use on vegetables, including brassica and cucurbits. In 2010 Gowan received US EPA approval for Scorpion 35SL for use on cucurbits, fruiting vegetables, brassicas, potatoes, grapes and leafy vegetables. In 2013 Mitsui Chemicals introduced FerterraStarkle CU Granule, a combination with chlorantraniliprole for use on seedling rice boxes in Japan. In 2015, Starkle 200 SG gained approval in Australia for use on cotton. In 2016 Hebei Veyong Bio-Chemical gained manufacturing approval in China for the active ingredient. | | | | | |

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| **Diquat** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Bipyridyl | 200 | 1958 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Reglone) | Chinese Companies | | |
| **Application** | Timing: | Post emergence | **Rate – (g/ha):** 400-800 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Potato, Cereals, Vine, Sunflower, Rape | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** paraquat, glyphosate, indaziflam | | | | | |
| **Recent History:**  Non-selective herbicide whose main use is as a crop desiccant mainly on soybeans, potatoes, cereals, peas, beans and a range of other crops. Significant sales are also achieved in mixtures with paraquat in some markets, notably Japan and parts of Europe, where the sale of paraquat alone is precluded. Has received re-registration in the EU until the end of June 2018. Launched in the UK in 2008 as Retro as a direct replacement for PDQ (paraquat chloride) for use on potatoes, sugarbeet and vegetables. In 2014 Bayer launched Specticle Total (diquat, glyphosate and indaziflam) for non-crop use in the USA. | | | | | |

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| **Disulfoton** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1958 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Di-Syston) |  | | |
| **Application** | Timing: | Foliar, Soil,  Seed treatment, Fumigant | **Rate – (g/ha):** 1100-3800 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, F&V | A wide range of insects and mites. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad spectrum organophosphorus insecticide offering good control of aphids, as such it is used for the control of vectors for viral diseases. Not supported through re-registration in the EU, where it left the market in 2003. In 2009 the US EPA cancelled all uses of the product. In 2010 Argentina’s Senasa banned the import, export, production, use and sale of the product in the country. | | | | | |

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| **Dithianon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | 55 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Delan) |  | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Vine | Downy mildew, Excoriosis | | |
| Pome fruit, Vine, F&V, Plantation crops | A wide range of diseases | | |
| **Main Mixture Partners :** cymoxanil, kresoxim-methyl, dimethomorph | | | | | |
| **Recent History:**  Contact fungicide that offers a wide spectrum of activity against foliar diseases predominantly of fruit trees and vines, particularly downy mildew on vines and apple scab. Has received EU approval. | | | | | |

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| **Dithiopyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | <30 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Dimension, Scoop) | None | | |
| **Application** | Timing: | Pre-emergence, Post-emergence | **Rate – (g/ha):** 280-560 |
| **Main Crops** | **Main Pests** | | |
| Turf, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Marginal niche pyridine herbicide for control of barnyard grass (*Echinochloa* spp.) and various broadleaved weeds in turf. Introduced by Monsanto in 1994, sold to Rohm & Haas and now part of Dow. Used in niche non-crop markets in high value sectors, notably in the USA and Japan. Achieved re-registration in Canada in 2009. Under registration review in the USA with completion expected in 2019. | | | | | |

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| **Diuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | 150 | 1954 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Drexel (Drexel Diuron) | DuPont, Adama, UPL, Nufarm, Sagrochem, Nitrokemia, Dow, IPiCi, Ancom, Nortox, Bharat Rasayan, Arysta | | |
| **Application** | Timing: | Pre-emergence | **Rate – (g/ha):** 225-6700 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Cotton, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :**  thidiazuron, hexazinone, amitrole, paraquat, oryzalin, flumioxazin, aminotriazole, glyphosate, linuron, terbuthylazine | | | | | |
| **Recent History:**  Commodity herbicide, manufactured by many companies, offering pre-emergence control of a wide range of grass and broadleaved weeds with a long duration of action. The major markets for the product are on sugarcane, cotton, soybeans, cereals, fruit (particularly in orchards) and vegetables, whilst it is also important in non-crop sectors. Irrigation and drainage use was cancelled in Australia in 2005 and most other uses were banned in 2011, except for antifouling paints and algal control. In 2010 Monsanto entered an agreement with Makhteshim (now Adama) under which it will license Roundup Ready products for use with diuron as Cotton Pro. In 2011 Adama acquired DuPont’s global non-mixture diuron business, with this being followed in 2013 by the addition of the cotton herbicide Direx 4L to Monsanto’s Roundup Ready Plus programme. Registered in Canada under certain risk mitigation measures but still used on asparagus and grapevines, as well as retaining non-crop usages. EU re-registration has been achieved. | | | | | |

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| **Dodemorph** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Meltatox) | None | | |
| **Application** | Timing: | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Ornamentals | Powdery mildew | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Morpholine fungicide of minor commercial significance, now largely limited to use on ornamentals for powdery mildew control. Achieved re-registration in the EU for use on ornamentals in glasshouses. | | | | | |

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| **Dodine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Syllit) | None | | |
| **Application** | Timing: | Foliar,  Post-harvest treatment | **Rate – (g/ha):** 650-3000 |
| **Main Crops** | **Main Pests** | | |
| Pome fruit, F&V | Scab, others | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Guanidine-based contact fungicide originally developed by Kenogard. Chimac Agriphar acquired dodine from Aventis in 2000, with this business subsequently passing on to Arysta / Platform. Foliar fungicide with some curative activity used predominantly on fruit (scab on apples and pears) and also with some applications on vegetables. The product is marketed by a number of companies under licence but is of limited commercial significance. Has been re-registered in the EU. | | | | | |

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| ***Drechslera monoceras*** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Tasumart) | None | | |
| **Application** | Timing: | Pre- and Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Grass weeds (*Echinocloa*) | | |
| **Recent History:**  Conidia (fungal spore) from the fungal plant pathogen *Drechslera monoceras*, used to control *Echinochloa crus-galli* (barnyard grass)*.* Water management, application timing and temperature are important factors on the herbicidal efficacy of the product.Registration approved in Japan in 2004, and introduced in 2005. International use pending. | | | | | |

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| **Edifenphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Hinosan) | FarmHannong | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 450-800 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice blast, Sheath blight, Stem rot | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Once an important product for rice blast treatment on the Japanese market, also with activity against sheath blight and stem rot. Now superseded by more recent introductions. Has not been approved for use in the EU. | | | | | |

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| **Emamectin benzoate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural product | 205 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Proclaim, Affirm, Denim) | Daqing Zhifeng | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 8 – 11 |
| **Main Crops** | **Main Pests** | | |
| F&V, Maize, Cotton, Rice, Soybean | Lepidoptera, Spodoptera: beet and fall armyworm, cabbage wireworm, corn earworm, diamondback moth, cross-striped and imported cabbageworms, and soybean/cabbage loopers | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Semi-synthetic avermectin derivative acquired by Syngenta as part of Merck’s agrochemical business. Perceived as a natural product, it has gained market share in the fruit & vegetables sector where older chemistries have suffered from regulatory action. Initially introduced in Japan, Korea, the USA, Taiwan, Israel, Australia and Mexico. Approved in Spain, Italy, Hungary and Portugal in 2010. Forms an important part of Syngenta’s insecticide portfolio along with the related abamectin. Initially refused registration in Brazil, although the product received emergency import and use authorisation for the control of corn earworms on cotton and soybeans in 2013 to 2017. Subsequently, Brazil’s Anvisa approved the a.i. in October 2017. EU approval has been received. Syngenta launched Enfold in the USA in 2015 for the control of lepidopteran pests on herbaceous and woody ornamentals. | | | | | |

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| **Endosulfan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organochlorine | 40 | 1958 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Excel Crop Care (Thiodan) | Adama, Atul, Coromandel, Rallis, Nortox, Sinon, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 350-700 |
| **Main Crops** | **Main Pests** | | |
| F&V, Sugarcane, Soybean | A wide range of insects, mites and nematodes | | |
| Cotton | Aphid, Boll weevil, Mites, Thrips | | |
| **Main Mixture Partners :** deltamethrin, methomyl | | | | | |
| **Recent History:**  Broad-spectrum organochlorine insecticide used in a wide range of crop outlets. Similar to most of the other organochlorines, use of the product is now limited by regulatory action. In 2011, following a decision by India and China to remove support for the product, it was included on the Stockholm Convention list of Persistent Organic Pollutants, effectively heralding a worldwide ban coming into effect in 2012. This action followed a number of moves that had limited the distribution of the product, with all registrations in the USA being voluntarily withdrawn following an agreement in 2010. Bans are also in place in Brazil, Australia, China and Argentina, as well as several other country markets. In addition, the product has been refused re-registration in the EU. In May 2011 the Indian Supreme Court banned the production and sales of endosulfan in the country, although exports are still being permitted. As a result, Excel Crop Care decided to suspend production and marketing of the product in the country. | | | | | |

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| **Endothal** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1951 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Aquathol) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 400 |
| **Main Crops** | **Main Pests** | | |
| Non-crop, Potato, Cotton | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Speciality herbicide for weed and algae control in aquatic situations, with minor usage in defoliation of cotton and potatoes. Now of minor commercial value. Not re-registered in the EU. Deemed eligible for re-registration in the USA where it is currently under review, providing certain risk mitigation measures are taken. | | | | | |

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| **Enestroburin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <10 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sinochem / Shenyang Research Inst. | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 250-500 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Powdery mildew | | |
| F&V | Downy mildew, *Alternaria* blotch | | |
| **Recent History:**  Developed as SYP-Z071, and introduced in China for use on various crops to control powdery and downy mildew. One of a number of strobilurin fungicides developed by Shenyang. | | | | | |

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| **Epoxiconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 490 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Opus, Opal, Opera, Adexar) | Adama, Sinochem, FMC | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 125 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Brown rust, *Septoria* leaf spot, Yellow rust | | |
| Soybean | Asian Rust, Powdery mildew | | |
| Maize, Turf, Rice | Wide range of Diseases | | |
| **Main Mixture Partners :**  carbendazim, kresoxim-methyl, pyraclostrobin, fenpropimorph, tridemorph, boscalid, isopyrazam, fluxapyroxad | | | | | |
| **Recent History:**  One of the most active fungicides in the triazole class, offering curative control of many of the major foliar diseases of cereals. The key markets for the product are cereals in Europe and soybeans in Brazil. Although the product has suffered from patent expiry, the impact on sales has been limited as in these key markets it is primarily sold in a mixture with the patented pyraclostrobin. Also used in many mixtures with morpholines and strobilurins and finds uses to control rust in coffee; and black and yellow sigatoka in bananas; as well as a number of significant diseases on sugarbeet rice and peanuts.  Several mixture products have been introduced by BASF, including with kresoxim-methyl for use on rice; with pyraclostrobin for use on maize, soybeans and cotton; with boscalid for cereals; with fluxapyroxad for soybeans and cereals; and with metconazole. In 2013 Syngenta received approval for Seguris (epoxiconazole with isopyrazam) for use on cereals in Germany. In 2014 Sinochem commenced manufacture of the product, which will be marketed as Rivet in Australia.  In 2016 BASF launched Ativum EC (epoxiconazole, fluxapyroxad and pyraclostrobin) to control soybean rust, root rot, powdery mildew and leaf spot of soybeans in Brazil. In 2017, BASF launched adexar (epoxiconazole and fluxapyroxad) for Indian cereals. | | | | | |

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| **EPTC** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Eptam) | Tri Chem, Sagrochem, Oxon, Nitrokemia, Adama | | |
| **Application** | **Timing:** | Pre-plant incorporated | **Rate – (g/ha):** 1500-7000 |
| **Main Crops** | **Main Pests** | | |
| Potato, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum, low-cost pre-plant incorporated grass and broadleaved weed herbicide, active against perennial weeds including *Agropyron repens* (couchgrass) and sedges. Major sales were achieved on maize as Eradicane with the safener dichlormid; however, these have now declined due to competition from recently introduced products and a shift to post-emergence weed control. Tri Chem (through Cedar Chemical) acquired the rights to manufacture and sell EPTC outside the EU and North America in 2000, however the product was not supported through re-registration in the EU. Gowan acquired the rights to the product in the NAFTA region from Syngenta in 2003. | | | | | |

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| **Esfenvalerate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 110 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Sumi-alpha) | Valent, Ihara, DuPont, BASF | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 5-50 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cereals, Soybean | A wide range of insects and mites | | |
| Potato | Colorado beetles, Aphid | | |
| Cotton | Boll weevil, Bollworm, Other Lepidoptera, Thrips | | |
| **Main Mixture Partners :**  fenitrothion | | | | | |
| **Recent History:**  Resolved pyrethroid with a wide range of crop and non-crop applications. Has largely replaced fenvalerate in most developed markets, with the leading regions being Europe and NAFTA. The first non-NRDC resolved pyrethroid to reach the market. Now a mature product, with sales affected by the success of *B.t.* cotton. Has received re-registration in the EU. Nufarm undertake toll manufacture, formulation and packaging of the product as Sumi-alpha in Australia, with Sumitomo distributing the product via its Australian subsidiary. Nufarm market the product in Hungary, Romania and Ukraine. In 2014 Sumitomo Chemical acquired DuPont’s Asana (esfenvalerate) business in the USA, with distribution to be undertaken by Valent, branded as Asana XL. | | | | | |

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| **Esprocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Spark Star) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 4000 |
| **Main Crops** | **Main Pests** | | |
| Rice, Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :**  diflufenican, dimethametryn, pyrazosulfuron-ethyl, imazosulfuron | | | | | |
| **Recent History:**  Carbamate herbicide offering control of annual weeds in rice, including barnyard grass (*Echinocloa* spp.). Its main usage has been in ‘one-shot’ rice herbicide formulations, notably Fujigrass and Sparkstar. Sales are now in decline as more recent introductions have taken leading positions in this market. In 2004 the rights in the major markets of Japan and Korea were divested by Syngenta to Nissan Chemical. | | | | | |

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| **Ethaboxam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Carboxamide | <10 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical(Guardian, Tellus) | None | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 125 – 250 |
| **Main Crops** | **Main Pests** | | |
| Maize, F&V | Downy mildew and late blight | | |  | |
| **Main Mixture Partners :** dimethomorph, clothianidin, ipconazole, metalaxyl, propineb | | | | | |
| **Recent History:**  Thiazolecarboxamide fungicide for the control of oomycete diseases, introduced in Korea in 1999, the second product from LG Chemical’s in-house R&D effort. Sumitomo Chemical acquired ethaboxam from LG Life Sciences in 2011, with LG toll manufacturing the product. Sumitomo has developed the product mainly for use as a seed treatment. Registration for use on fruit and ornamentals was gained in Central Europe in 2004. Although the registration dossier in the EU was been deemed complete, it has not been included on Annex 1. A component of Valent’s Intego Suite seed treatment product for soybeans in the USA, with clothianidin, ipconazole and metalaxyl. Valent gained US approval of the brand Elumin (ethaboxam) for use on tuberous and corm vegetables in 2017. Nufarm also received a label expansion in Canada for Intego Solo (ethaboxam), for use on field peas and sunflowers in 2017. | | | | | |

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| **Ethalfluralin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | 50 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Sonalan) | None | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 525-1900 |
| **Main Crops** | **Main Pests** | | |
| Peanuts, Sunflower, Rape, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Dinitroaniline herbicide more suited to use in cooler climates than Treflan (trifluralin). Finds sales in a number of niche markets, primarily in the USA. Has not been re-registered in the EU. In 2015 Gowan acquired Dow’s global dinitroaniline herbicide business. | | | | | |

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| **Ethametsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <10 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Muster) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 10-120 |
| **Main Crops** | **Main Pests** | | |
| Rape | Broadleaved weeds | | |
| **Main Mixture Partners :** diflufenican, quizalofop | | | | | |
| **Recent History:**  The first sulfonylurea for use on canola, first launched in Canada in 1990. One of only a few herbicides developed specifically for use on the crop. Registration in the USA was achieved in 2001, with usage in a tank mix with quizalofop recommended. Use in China to be phased out following a registration evaluation. In 2017 DuPont agreed to divest ethametsulfuron-methyl to FMC as part of the closing conditions for the Dow-DuPont merger. | | | | | |

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| **Ethephon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 195 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (PREP) | Rallis, Chinoin, Nufarm | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 125-600 |
| **Main Crops** | **Main Pests** | | |
| Cotton, Cereals, F&V, Plantation crops, Pome fruit, Sugarcane | n.a | | |
| **Main Mixture Partners :** cyclanilide, mepiquat-chloride, chlormequat, trinexapac-ethyl | | | | | |
| **Recent History:**  One of the leading plant growth regulators, used to promote leaf drop and boll opening in cotton and pre-harvest ripening in many crops. Also helps prevent lodging in cereals, promotes uniform ripening in coffee and speeds up ripening and sugar development in sugarcane and fruits. Despite its age and generic competition, ethephon maintains a steady sales return, although this is dependent on conditions in the cotton market. Granted Annex 1 inclusion in the EU with approval extended until the end of July 2018. Etigra, since acquired by Nufarm, obtained the Super Boll PGR brand from DuPont in 2008. Nufarm acquired DuPont’s ethephon-based harvest aids in the same year. | | | | | |

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| **Ethion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Ethion) | Rallis, Pesticides India, Bharat Rasayan, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-6000 |
| **Main Crops** | **Main Pests** | | |
| Cotton, F&V | Insects, Mites, Aphids, Thrips, Leafhoppers | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity broad-spectrum insecticide with miticidal activity used on a wide range of food, fibre and ornamental crops. Like many older organophosphates, the product is now subject to regulatory action; however it does achieve sales in developing markets. The EPA has issued a cancellation order for all uses in the USA, the product is no longer being sold in Canada and it is not supported through re-registration in the EU, although some essential uses remain. Has also been banned in New Zealand. Passed to FMC following its acquisition of Cheminova. | | | | | |

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| **Ethiprole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other - Pyrazole | 50 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Curbix, Kirapp) | BASF (Europe only) | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Rice, Stored grains, Tea, F&V | A wide range of insects | | |
| **Main Mixture Partners :**  ferimzone, phthalide | | | | | |
| **Recent History:**  First introduced in 2005 in Japan for use on rice, the product has good residual activity against sucking pests. Bayer divested the European rights to the product to BASF following the acquisition of Aventis. Introduced in Brazil in 2010 as Curbix for use on sugarcane and rice. | | | | | |

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| **Ethofumesate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | 65 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Betanal) | DuPont, Adama, UPL, Punjab Chemicals | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 1000-2000 |
| **Main Crops** | **Main Pests** | | |
| Sugarbeet | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** desmedipham, phenmedipham | | | | | |
| **Recent History:**  Broad-spectrum sugarbeet herbicide used mostly in tank mixtures for pre-emergence application. Now a commodity product but still holding a steady share of the sugarbeet herbicide market. In 2016 the EU granted a 15 year approval. In 2010 the Hong Kong-based company Willowood began operations in the USA, with the product representing part of its initial range. | | | | | |

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| **Ethoprophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Mocap) | None | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** 1120-2240 |
| **Main Crops** | **Main Pests** | | |
| F&V, Peanuts | Soil insects, Cutworm, Wireworm | | |
| Potato | Nematodes, Colorado beetles | | |  | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Soil applied organophosphorus nematicide with a wide range of crop applications. The product has achieved registration in the EU, with risk mitigation measures, and although some labels have been lost in the USA, particularly on some fruit & vegetable and fodder crops, the main usages have been retained. Amvac acquired the product from Bayer in 2010 and subsequently appointed Certis Europe as the exclusive distributor of the product in the UK, Ireland, France, the Netherlands, Belgium, Spain, Portugal and Italy. | | | | | |

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| **Ethoxyfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | <10 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Budapest Chemical Works (Buvirex) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 20-30 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Cereal herbicide developed for *Gallium aparine* control (cleavers), also active against a number of broadleaved weeds. | | | | | |

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| **Ethoxysulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Sunrice, Gladium) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 10-120 |
| **Main Crops** | **Main Pests** | | |
| Rice, Sugarcane | Broadleaved weeds | | |
| **Main Mixture Partners :**  cyhalofop-butyl, fenoxaprop-P-Ethyl | | | | | |
| **Recent History:**  Sulfonylurea herbicide with activity against broadleaved weeds and sedges. Now finding use in a number of ‘one-shot’ formulations which has resulted in sales improvement. Also has potential for introduction on cereals and turf, with approval for use on sugarcane received in Australia in 2008. EU approval expired in 2014, with no applications for renewal received. In 2010 the Chinese agrochemical company Zhejiang Tide Cropscience commenced development of a generic version, with plans to produce 250 tonnes a year. | | | | | |

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| **Etobenzanid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Hodogaya (Hodocide) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 150 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :**  daimuron, imazosulfuron | | | | | |
| **Recent History:**  Dichloroaniline pre- and early post-emergence herbicide for grass weed control, especially barnyard grass (*Echinochloa* spp.), in rice. | | | | | |

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| **Etofenprox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 80 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Trebon) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 150-450 |
| **Main Crops** | **Main Pests** | | |
| Rice | White backed plant hopper, Brown plant hopper, Green leafhopper, Leaf beetle, Water weevil | | |
| F&V, Cereals, Rape | A range of insects and mites | | |
| **Main Mixture Partners :**  dinotefuran, azoxystrobin, kasugamycin, tricyclazole, tebufloquin | | | | | |
| **Recent History:**  Aryl alkyl ether derivative with pyrethroid-like activity. Unlike other pyrethroid-like products, etofenprox achieves significant sales on rice due to a low fish toxicity profile. Usage has increased through registration on additional crops such as vegetables and cotton, and through outward licensing, which has assisted in maintaining sales. Has achieved re-registration in the EU until 2021. | | | | | |

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| **Etoxazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Baroque, Zeal, Borneo) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Tea, Ornamentals, Trees, F&V, Pome fruit, Vine | Mites, Aphids | | |
| **Main Mixture Partners :** fenpropathrin | | | | | |
| **Recent History:**  Diphenyloxazoline product that inhibits the acarine moulting process, active against egg, larval and nymph stages of mites and juvenile aphids. Discovered and co-developed with Yashima Chemical, introduced in Japan in 1998 and marketed alone and in a combination with fenpropathrin. Marketed as Borneo for use on vines and orchards in a number of country markets, including France, Italy, the UK, South Korea, Taiwan, Turkey, Brazil and the USA. Marketed by Valent in the USA and Canada as Tetrasan for use on ornamentals, and as Zeal, Secure and Zoom for use on cotton, fruit, nuts, vines and maize. Approved in Australia in 2004 for use on cotton and apples, and has achieved Annex 1 approval in the EU. EU approval which was due to expire in 2017 has been extended by one year to July 2018. In 2016 Valent’s Zeal SC received registration in the USA for the control of spider mites on soybeans. Zeal has been included the Monsanto/Valent Roundup Ready Plus Crop Management Solutions Scheme for 2018. | | | | | |

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| **Etridiazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Other azole | <10 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Terrazole) | None | | |
| **Application** | **Timing:** | Foliar, Soil  Seed treatment**,** | **Rate – (g/ha):** 100-1000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice | Damping off, Diseases | | |
| **Main Mixture Partners :**  thiophanate | | | | | |
| **Recent History:**  Broad-spectrum fungicide mainly as a seed treatment for the control of damping off (*Pythium* and *Phytophthora*) diseases in many vegetable crops. Has been re-registered in the EU. A new formulation, Terramaster, was introduced for the control of *Pythium* on cotton and tobacco in 2001. Manufactured by Chemtura as Terrazole, with the company now operating under the Arysta LifeScience name following the 2015 acquisition by Platform Specialty Products. | | | | | |

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| **Famoxadone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 65 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Equation, Tanos) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 50 – 200 |
| **Main Crops** | **Main Pests** | | |
| Potato, F&V | A wide range of diseases | | |
| Vine | Downy mildew, Excoriosis | | |
| **Main Mixture Partners :** flusilazole, cymoxanil, mancozeb, flusilazole | | | | | |
| **Recent History:**  Oxazolidinedione fungicide, active through inhibition of mitochondrial electron transport, specifically inhibiting cytochrome bc1, the same as the strobilurins. Famoxadone finds significant usage in specialty crops where it is particularly effective against potato downy mildew, late blight and potato early blight, and is sold in mixtures with cymoxanil and mancozeb. UPL market the product in some vine sectors in France. Approval for use in the EU has been extended until the end of June 2018. | | | | | |

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| **Fenamidone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Consento, Censor) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 75-125 |
| **Main Crops** | **Main Pests** | | |
| Potato | A range of diseases | | |
| F&V, Vine | Downy mildew | | |
| **Main Mixture Partners :**  fosetyl-aluminium, mancozeb, cymoxanil, propamocarb-hydrochloride | | | | | |
| **Recent History:**  Imidazolinone fungicide for the control of oomycete diseases. The product is sold in combination with mancozeb as Sereno and Sagaie for use on potatoes (Gemini in Germany); with fosetyl as Elicio and Verita; and with cymoxanil as Arte and Duofast for use on vine. Has received Annex 1 approval in the EU, with this being extended to the end of July 2017. Registered for use on ornamentals in the USA in 2004 and for use on potatoes in Japan in 2005 and Canada in 2008. Consento, a mixture with propamocarb-hydrochloride, received registrations in 2009 in Brazil for late blight control on tomatoes and potatoes and in Mexico to control downy mildew on vegetables. Approved in Canada in 2014 as Reason, a seed-piece treatment on potatoes to control seed-borne late blight. Bayer introduced Consento, a mixture with propamocarb, in Italy in 2016. | | | | | |

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| **Fenamiphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Nemacur) | Adama, Gharda | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** 800-11000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops | A range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Systemic nematicide whose major markets are on fruit & vegetables, primarily bananas, citrus, and vine (including *Phylloxera*). Originally introduced by Bayer, the rights to the product in all regions except Europe and Argentina were divested to Amvac in 2010. Fenamiphos has a broad range of activity against root-knot and cyst forming nematodes, as well as secondary activity against foliage sucking insects, including aphids and mites. The product is now subject to regulatory action, and all US registrations were cancelled at the request of Bayer. However, the product is registered in the EU. Chinese authorities have halted accepting applications for field testing, registration or manufacture permits for the product, with these measures to lead to an eventual ban. In 2015 Amvac acquired Adama’s Nemacur assets in Europe, with Adama acting as distributor for the product in Greece, Italy, Portugal and Spain. Has been banned for use in New Zealand and Australia. | | | | | |

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| **Fenamistrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <10 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Shenyang Research Institute | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Blast | | |
| Cereals | Powdery mildew, leaf rust, stripe rust | | |
| F&V | Pear scab, banana leaf spot | | |
| **Recent History:**  Methoxyiminoacetamide strobilurin, also known as xiwojunan. Developed as SYP-1620, the product was provisionally registered in China in 2005 and introduced in 2008. Used mostly for rice blast control. | | | | | |

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| **Fenarimol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Others | <10 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Rubigan) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 35-100 |
| **Main Crops** | **Main Pests** | | |
| Vine | Powdery mildew | | |
| F&V, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** quinoxyfen | | | | | |
| **Recent History:**  Systemic pyrimidine fungicide with preventative, curative and erradicant activity used predominantly on vines and top fruit with limited use also in turf grass (snow mould), various tree crops (apple scab and rusts; leaf spot in cherries) and nuts. Acquired by Gowan from Dow in 2002. A new formulation, Vintage, was launched in the USA in 2004 to control powdery mildew on grapes. 18 of 42 tolerances have been revoked in the USA and registrants have agreed to remove residential uses of the product. Has not been re-registered in the EU. The Indian Ministry of Agriculture has imposed a ban on fenarimol to commence in 2018. | | | | | |

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| **Fenazaquin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Magister) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 56-560 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Miticide developed by Dow and targeted at the citrus, tree fruits and vine markets in Europe. The product is active against both eggs and motile stages of mites. Usage of the product has been extended to other geographies, particularly Asia, providing further potential for growth, however still of limited commercial significance and divested by Dow to Gowan in 2002. Introduced by Sipcam in France in 2002 for use on vines. Has been re-registered in the EU. Received approval in the USA in 2010 as Magus for use on ornamentals, as well as non-bearing fruit and nut trees. In 2016 Gowan received US approval for Magister for the control of mites on several crops, as well as powdery mildew on cherries. In 2017 Magister was approved in the US as a miticide on hops. | | | | | |

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| **Fenbuconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | <30 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Impala, Indar) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Vine | Black Rot | | |
| F&V, Plantation crops | A wide range of diseases | | |
| **Main Mixture Partners :** prochloraz, carbendazim, mancozeb | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide predominantly applied in mixtures on various fruit crops for powdery mildew control and for black rot and grey mould on vines. Acquired by Dow as part of Rohm & Haas in 2001. Has received EU registration extension until the end of April 2021. Achieved registration for use on stone fruit in Canada in 2006. An important product in the blueberry sector in the USA. Currently under US EPA registration review. Approved in the US for use on various fruit and nut crops as well as peppers, sugarbeet and wheat. | | | | | |

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| **Fenbutatin oxide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 40 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Torque) | BASF, Oxon, SePRO | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-2000 |
| **Main Crops** | **Main Pests** | | |
| Citrus, F&V | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Contact organotin acaricide with residual activity against all motile stages of mites. Major usage is on citrus, with applications on many fruit crops and vine. Often used in combination with specific miticides to broaden their spectrum of activity. Maintains a steady share of the acaricide market. Registered in Canada, under certain risk mitigation measures. UPL acquired DuPont’s position in the product in 2007, building on their existing business following the purchase of Cerexagri. Phased out in the EU in 2014. Received re-registration in Australia in 2016. | | | | | |

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| **Fenhexamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 50 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Teldor, Password) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500 - 750 |
| **Main Crops** | **Main Pests** | | |
| Vine | *Botrytis* | | |
| F&V, Ornamentals | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Hydroxyanilide product active against many of the common moulds and rot diseases of fruit and vegetables. Now an established product for *Botrytis* control on vines, and also controls a wide range of diseases such as powdery mildew, resulting in more limited sales on fruit & vegetables and ornamentals. SePRO market the product for powdery mildew control on ornamentals in the USA, with Arysta marketing the product for use on fruit & vegetables in the country. In 2010 Bayer launched a new formulation, Teldor Plus, in Italy for pre-harvest use on vines and fruit & vegetables to control grey mould and *Monilia* spp. Granted additional approvals in Greece and Portugal in 2011 for use on various fruit and vegetables. Has received re-registration in the EU until 2030. It is under re-evaluation in Canada. | | | | | |

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| **Fenitropan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1981 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Egypt Pharmaceutica (Volparox) | None | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** 40-200 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Bunt, *Fusarium*, Seedling blight | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Cereal seed treatment with activity against *Fusarium* and *Tilletia* of wheat. Also active against powdery mildew on apples and seedling blight of rice. A minor product commercially. | | | | | |

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| **Fenitrothion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 55 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Sumithion) | FMC, Rallis, Adama, Sinon | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 150-2000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Brown plant hopper, Green leafhopper, Leaf beetle, Leaf miner, Leaf rollers, Stem borer, Stinkbug | | |
| Soybean, Plantation crops, F&V, Pome fruit | A wide range of insects and aphids | | |
| **Main Mixture Partners :**  esfenvalerate, fenvalerate | | | | | |
| **Recent History:**  Mature organophosphorus insecticide with a broad range of crop applications against chewing, sucking and boring insects. Has not attracted the same level of generic competition as other major products in the class. Re-registration in the EU has been refused and most usages in Australia were banned in 2004. Banned for use on sunflowers in Argentina in 2007, and for all uses in India, except for locust control in certain desert areas. In 2012 Nufarm took on the marketing of the product in Ukraine for Sumitomo. New Zealand introduced a ban in 2016. | | | | | |

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| **Fenoxanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Carboxamide | <10 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku  (Achieve) | None | | |
| **Application** | **Timing:** | Foliar or into the paddy water | **Rate – (g/ha):** 120-150 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice Blast | | |
| **Main Mixture Partners :** flutolanil, dinotefuran, etofenprox, thifluzamide | | | | | |
| **Recent History:**  A systemic protectant fungicide jointly developed by Nihon Nohyaku (NNF 9425) and Cyanamid/BASF (AC382042). Approved in Japan in 2001 as Achieve (as sole active ingredient); with flutolanil (as Achieve Moncut), with dinotefuran (Achieve Starkle) and with flutolanil and etofenprox (as Achieve Moncut Trebon). | | | | | |

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| **Fenoxaprop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 180 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Puma) | Nufarm, FMC (Foxtrot) | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 200-500 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Rice, Soybean | Grasses | | |
| **Main Mixture Partners :**  mefenpyr, clethodim, iodosulfuron, mefenacet, diclofop-methyl, pyrasulfotole, bromoxynil, fluroxypyr, dicamba | | | | | |
| **Recent History:**  Graminicide for post-emergence grass weed control, predominantly on cereals in combination with safeners. New formulations have been introduced in the USA, notably Ricestar for rice and Option for maize. Nufarm hold the rights to two formulations in Belgium and Germany. Fenoxaprop has not been supported through EU re-registration, but fenoxaprop-p received approval in 2008, which was subsequently introduced by Cheminova (now FMC) as Foxtrot in Denmark in 2009 for the control of wild oats. Bayer launched Tundra, a mixture with pyrasulfotole and bromoxynil, in Canada in 2010. In 2014 Nufarm launched Last Call, which also contains fluroxypyr and dicamba, for use on turf. | | | | | |

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| **Fenoxasulfone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other - Isoxazoline | <10 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (KumiStar) | None | | |
| **Application** | **Timing:** | Pre- and Post-emergence | **Rate – (g/ha):** 200 |
| **Crops** | **Main Pests** | | |
| Rice | Grass and broadleaf weeds. | | |
| **Main Mixture Partners :**  bensulfuron-methyl, benzobicyclon, bromobutide | | | | | |
| **Recent History:**  Isoxazoline herbicide developed by Kumiai / Ihara as KIH-1419. Active through the inhibition of very long chain fatty acid biosynthesis. A sister herbicide of pyroxasulfone which is used for upland crops such as corn, wheat, soybean and other crops. Provides excellent efficacy on a wide range of annual weeds in paddy rice. Physical characteristics allow the product to provide stable efficacy under flooded rice culture systems and prevent the risk of leaching into groundwater. Registered in Japan in 2014 for use on rice, and also on turf. In 2017 Kumiai registered two new fenoxasulfone based products to the Japanese market, Spada WG (fenoxasulfon) and Yabusame Jumbo (pyraclonil, pyrimisulfan and fenoxasulfone). | | | | | |

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| **Fenoxycarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <10 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Insegar) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500 |
| **Main Crops** | **Main Pests** | | |
| Vine | Leaf rollers | | |
| Pome fruit, Ornamentals, F&V | A wide range of insects and mites. | | |
| **Main Mixture Partners :** lufenuron | | | | | |
| **Recent History:**  Carbamate insecticide with insect growth regulator activity. The major market is for the control of fire ant and white fly in non-crop situations. Main crop uses are on pome fruit (codling moth), citrus (scale insects) and vine. All US registrations were cancelled in 2010 at the request of Syngenta. Has gained re-registration in the EU. | | | | | |

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| **Fenpropathrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 50 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Rody, Danitol) | LG Chemical | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-225 |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice, Soybean, Cotton | Aphid, Bollworm, Budworm, Other lepidoptera, Whitefly, Armyworm, Leaf minor, Leaf roller, Thrips | | |
| **Main Mixture Partners :** hexythiazox, acetamiprid, thiophanate-methyl, omethoate | | | | | |
| **Recent History:**  Broad-spectrum insecticide with activity against soil borne pests and mites. A niche product in the pyrethroid market. Marketed by Valent in the USA where it is used on vine, citrus, cucurbits, cole crops, tomato and cotton. Valent market a citrus spray under the Danitol brand. Not registered in the EU. In 2012 Nippon Soda gained registration for the product in a mixture with acetamiprid and thiophanate-methyl as Mos Topsin in Japan. | | | | | |

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| **Fenpropidin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | 60 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Tilt Turbo) | Adama | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-750 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sugarbeet | Brown rust, Powdery mildew, Yellow rust | | |
| **Main Mixture Partners :** difenoconazole, propiconazole | | | | | |
| **Recent History:**  Piperidine fungicide offering morpholine-like curative control of powdery mildew (*Erysiphe graminis*) in cereals. At one time Syngenta were involved with fenpropimorph but switched to fenpropidin, which had a longer patented life. Much of the generic competition has been directed at fenpropimorph, to the benefit of fenpropidin. Increasing competition is evident from new introductions; however sales remain closely linked to the performance of the EU cereal fungicide market. Also used in many mixtures to provide a powdery mildew control element. Marketing rights in the Nordic countries were divested to Adama on the formation of Syngenta. Re-registration has been achieved in the EU until the end of 2018 and in the USA. | | | | | |

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| **Fenpropimorph** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | 70 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Capalo, Champion) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-700 |
| **Main Crops** | **Main Pests** | | |
| Cereals  Soybean | Brown rust, Powdery mildew, Yellow rust  Soybean rust | | |
| F&V | A range of diseases | | |
| **Main Mixture Partners :** epoxiconazole, kresoxim-methyl, flusilazole, azoxystrobin, prochloraz, propiconazole | | | | | |
| **Recent History:**  Morpholine offering curative control of powdery mildew in cereals. Widely used in many mixture formulations, notably with strobilurins and triazoles. Sales have been affected by more recently introduced competitive products as well as generic competition. Introduced as a wood preservative as Wolsin in the USA. Re-registration in the EU has been achieved, with approval extended until the end of April 2019. In 2017 BASF launched Versatilis (fenpropimorph) in Brazil for control of soybean rust. | | | | | |

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| **Fenpyrazamine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Pyrazolinone | <10 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Prolectus) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Vine, F&V | *Botrytis, Sclerotinia, Monilinia* | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Discovered and developed by Sumitomo as S-2188. Highly effective on *Botrytis, Sclerotinia and Monilinia* diseases. Approved in the EU in 2012, with introduction as Prolectus achieved toward the end of the year. Received registration in the USA in 2013, with Valent USA to market the product for use on almonds, lettuces, small fruits and ornamentals. Also introduced in South Korea in 2013. Further registrations are anticipated in Japan, Brazil, Chile and South Africa. Prolectus gained Australian approval for the control of grey mould on vines in 2016. Gained Australian approval for use on vines in 2016. | | | | | |

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| **Fenpyroximate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 30 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Danitron, Fujimite, Kiron) | SePRO | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Ornamentals, Plantation crops, Pome fruit | Mites, insects, psylla, leafhoppers, mealybugs | | |
| **Main Mixture Partners :** pyflubumide, fenpyroximate | | | | | |
| **Recent History:**  Broad-spectrum miticide with activity against larvae, nymphs and adults. The product rapidly gained a leading position in the important Japanese acaricide sector, a market noted for short product life cycles. The onset of resistance problems has resulted in significant market share being lost, although sales have been assisted by exports. In 2001 SePro registered the product for mite control in greenhouses in the USA as Akari, with an outdoor nursery label granted in 2005. Nihon Nohyaku’s US subsidiary Nichino America received the first crop registrations for the US market in 2004, for apples, pears, vines and cotton as FujiMite. Through an agreement with Nichino America, Engage Agro market the product in Canada. Re-registration in the EU has been achieved, with approval being extended until the end of April 2019. Gained approval in Japan in 2015 in the mixture product Doubleface Flowable (pyflubimide and fenpyroximate) for use on F&V, citrus, tea and ornamentals. Gained approval in Canada in 2016 for the control of mites and whiteflies on ornamentals and greenhouse crops. | | | | | |

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| **Fenthion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1961 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Lebaycid) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-1750 |
| **Main Crops** | **Main Pests** | | |
| F&V | Wide range of insects | | |
| Rice | Green leaf hopper, Yellow rice borer, Stinkbug, Water weevil | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorus insecticide of limited commercial significance. Main use is against rice pests, also for fruit fly control and minor applications in a range of crops. US re-registration was accepted, however Bayer voluntarily cancelled all labels in 2003. Many pre- and post-harvest uses have also been cancelled in Australia. Not re-registered in the EU. From 1st January 2018, fenthion is banned in India. | | | | | |

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| **Fentin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Inorganic | 55 | 1954 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Mertin) | Chinese Companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-600 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cotton, Soybean | A wide range of diseases | | |
| **Main Mixture Partners :**  maneb | | | | | |
| **Recent History:**  Organotin fungicide marketed as fentin hydroxide (Mertin 400) and fentin hydroxide (Du-Ter), with secondary insecticidal activity. The products have been refused Annex 1 listing in the EU and were removed from sale in 2003. The main market is now in Brazil where it finds significant usage on soybeans, cotton and fruit. The future of the Brazilian market remains uncertain following a court imposed ban on Syngenta’s Mertin 400 product after improper use. A commodity product now sold by many companies. | | | | | |

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| **Fentrazamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 45 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Bodyguard) | None | | |
| **Application** | **Timing:** | Post-emergence (in mixtures) | **Rate – (g/ha):** 200-300 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grass weeds | | |
| **Main Mixture Partners :** bensulfuron-methyl, pyrazosulfuron, pyrimisulfan, tefuryltrione | | | | | |
| **Recent History:**  Applied at transplantation providing broad-spectrum weed control, with long lasting efficacy. The application timing complements Bayer’s seedling box fungicide and insecticide application strategy with carpropamid and imidacloprid. Introduced in Thailand, Vietnam, Malaysia and the Philippines in 2000, followed by Japan in 2001 as Innova, a mixture with bensulfuron-methyl. Became one of the leading rice herbicides in South Korea, but now superseded by more recent introductions, although still used in a number of one-shot combinations in Japan. | | | | | |

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| **Fenvalerate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <30 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Sumicidin) | BASF, Rallis, Gharda, Atul, Bharat Rasayan, UPL, Isagro, Sinon, Coromandel | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-250 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Cotton, F&V, Rice | A wide range of diseases | | |
| **Main Mixture Partners :**  esfenvalerate | | | | | |
| **Recent History:**  The first synthetic pyrethroid available for agricultural usage, now of commodity status and superseded by newer generation products. The market has moved toward resolved pyrethroids in developed markets and the product has not been re-registered in the EU. The last US registrations were cancelled in 2008. | | | | | |

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| **Ferimzone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other | <10 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Blasin) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 300-800 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice blast, Rice leaf spot | | |
| **Main Mixture Partners :** phthalide | | | | | |
| **Recent History:**  Rice blast fungicide of minor significance sold in a mixture with phthalide. Also has activity against rice leaf spot and *Helminthosporium* blight. Formerly a Takeda product, now marketed by the Sumitomo/Takeda joint venture. | | | | | |

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| **Fipronil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Others | 495 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Regent) | Adama, Chinese and Indian companies | | |
| **Application** | **Timing:** | Foliar,  Seed treatment,  Soil applied | **Rate – (g/ha):** 6-200 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Soybean aphid, Stink bug, Lesser cornstalk borer | | |
| Rice | Brown plant hopper, Stem borer, Water weevil | | |
| Maize | Rootworm, European cornborer, Corn wireworm, Thrips | | |
| Sugarcane, F&V | A wide range of insects | | |
| **Main Mixture Partners :** probenazole, pyraclostrobin, thiophanate | | | | | |
| **Recent History:**  Active via the blockage of the gamma aminobutyric acid regulated chloride channel in the insect’s nervous system. Marketed in over 80 countries on a wide range of crops, with soybean now being the most significant, followed by rice. The product has achieved great success in the rice nursery box sector in Japan as a component of Dr Oryzae Prince along with the fungicide probenazole. The majority of current registrations are for soil applied and seed treatment uses; many foliar usages remain in development, however few registrations have been achieved in this sector. In 2011 Adama launched the first generic fipronil products in the USA. Has received registration in the EU, but restrictions have been put in place on bee-sensitive crops: bee toxicity issues had already led to suspensions in France in 2004, Italy in 2008 and China in 2009. Ourofino Agrociência launched Terra Fort in Brazil during 2016 for use on soybean, corn, cotton and beans. Available in some seed treatment platforms for cereals.  The most important outlet for fipronil is in the animal health sector for flea and tick control where it is sold as Frontline. Here it competes against imidacloprid and lufenuron, where it benefits from also having activity against ticks. Significant sales are also achieved in other non-crop areas, particularly for termite control and urban pest control. | | | | | |

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| **Flazasulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Katana) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 25-100 |
| **Main Crops** | **Main Pests** | | |
| Vine, Plantation crops, Turf | Grass weeds, Broadleaved weeds and sedges | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum sulfonylurea herbicide initially introduced for use on turf and subsequently developed by both Ishihara and Zeneca for food crop usage. The product reverted to Ishihara on the formation of Syngenta. Has received re-registration in the EU until 2032. It was introduced in Europe for use on vines by the ISK / FMC joint venture Belchim. Introduced by Belchim as Chikara in 2009 in the UK for weed control around farmyard buildings, gravel drives, tracks and static machinery. Approved for use on turf in the USA in 2007, followed by approvals for citrus, vines and sugarcane in 2012. | | | | | |

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| **Flonicamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 51 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara  (Ulala, Turbine, Teppeki) | FMC | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 50-100 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cotton, Pome fruit, Potato, Ornamentals | Aphids and other sucking insects including thrips, mealy bugs, plant bugs, whiteflies and hoppers | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyridinecarboxamide systemic insecticide developed by Ishihara. Whilst the product has similar chemistry to the neonicotinoids, it has a different mode of action. It is systemic and translaminar and demonstrates rapid anti-feeding activity, with broad insecticidal and aphicidal activity. Registered in the USA in 2005 for use on ornamentals in greenhouses and as Carbine for use on cotton, and expanded to potatoes, fruit and vegetables in 2007. FMC are the sole distributors in the Americas (except Argentina, Chile, Paraguay and Uruguay), UK, Spain and Portugal. FMC launched flonicamid as Turbine in Brazil in 2006, with further approvals received in Japan and China in 2007. Belchim markets the product in France, Germany, Belgium and Holland, and UPL market the product in India following an agreement in 2012. ISK gained registration for a new formulation in the Japanese market as Ulala Kunjozai in 2012. ISK’s Mainman gained approval for use in New Zealand in 2015 for use on potato and horticultural crops. EU granted an approval extension until 2023. Currently under registration review in the USA. | | | | | |

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| **Florasulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS | 190 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Primus, Boxer) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 3.75-10 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Broadleaved weeds especially *Galium aparine, Stellaria media, Matricaria* spp. and *Polygonum* spp. | | |
| **Main Mixture Partners :**  flumetsulam, MCPA, 2,4-D, fluroxypyr, clopyralid, pinoxaden, pyroxsulam, halauxifen, tritosulfuron | | | | | |
| **Recent History:**  Triazolopyrimidine herbicide for broad-spectrum broad leaf weed control in cereals, particularly cleavers, with a wide window of application. First introduced in Belgium, with launches subsequently taking place in a number of significant cereal-growing countries. Has achieved Annex 1 registration in the EU. Several mixture products have been introduced by Dow, including with fluroxypyr as Kart in France and Spitfire in the UK; in Australia and the USA with clopyralid as Torpedo; with pyroxsulam as Broadway Star; and more recently with halauxifen as Quelex in China and Zypar in Denmark.  Syngenta has exclusive third-party rights to the active ingredient in the US cereals sector, with Orion being launched in the country in 2008. Syngenta have also introduced mixtures with pinoxaden as Broadband and Axial TBC.  BASF launched Biathlon 4D, which also contains tritosulfuron, in Germany in 2013 and Spain in 2016, whilst in 2014, Cheminova (now FMC) launched Saracen in Denmark and Spitfire in Canada. In 2015 Adama introduced Outshine (florasulam and fluroxypyr) in Canada, followed in 2016 with Hotshot (florasulam and bromoxynil). | | | | | |

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| **Fluacrypyrim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Titaron) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 100-150. |
| **Main Crops** | **Main Pests** | | |
| Pome fruit, F&V | *Panonychus citri* (citrus), *Tetranychus urticae* and *P. ulmi* (apples), spider mites (pears) | | |
| **Main Mixture Partners :** chlorfenapyr | | | | | |
| **Recent History:**  Introduced in 2002 in Japan and South Korea, followed by China in 2003. The product is also marketed by Kumiai in the co-operative channel in Japan. Also sold in combination with chlorfenapyr. | | | | | |

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| **Fluazifop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 125 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Fusilade) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 200-750 |
| **Main Crops** | **Main Pests** | | |
| F&V, Soybean, Rape, Potato, Cotton | Grasses | | |
| **Main Mixture Partners :**  linuron | | | | | |
| **Recent History:**  Post-emergence graminicide for broadleaved crops now sold mainly in the resolved form fluazifop-P. The product rapidly gained success following introduction, but sales have since been impacted by the uptake of herbicide tolerant crops, particularly soybean and cotton. The resolved form has gained registration in the EU, although the non-resolved form has been refused re-registration. Fluazifop-p has also been approved in the USA. Ishihara gained Japanese registration for the product in a mixture with linuron as One Cross in 2012. Gained re-registration for use in Canada following special review in 2015. Approvals in Brazil were extended in 2016 to include Canola. | | | | | |

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| **Fluazinam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | 125 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Frowncide) | Ishihara | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 500 |
| **Main Crops** | **Main Pests** | | |
| Potato | Potato blight, *Sclerotinia* stem rot (white mould) | | |
| Soybean, F&V | A wide range of Diseases | | |
| **Main Mixture Partners :** metalaxyl, cymoxanil, mancozeb, thiophanate-methyl | | | | | |
| **Recent History:**  Broad-spectrum phenylpyridylamine contact fungicide chiefly for use on potatoes for the control of potato blight and white mould, particularly at the important tuber stage. Also active against grey mould and downy mildew on vines, apple scab and some peanut diseases. Zeneca (now Syngenta) acquired the distribution rights outside the Asia Pacific region in 1998. Also marketed by Syngenta as Allegro in Canada for use on potatoes, soybeans and vegetables, and as Secure for turf in the USA. Re-registration in the EU has been achieved with approval extended until the end of February 2019. Now off-patent and subject to significant generic competition. In 2010 Iharabras launched the product in a mixture with thiophanate-methyl as Certeza for seed treatment use on soybeans and kidney beans in Brazil. Cheminova (now FMC) also introduced the product in 2013 for potato blight control in Germany. Received continued approval for use in Canada in 2016 following a special review. | | | | | |

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| **Flubendiamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 443 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku, Bayer (Takumi, Belt, Phoenix, Fenos, Fame) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-90 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Cotton, Maize, Tea, Nuts, Rice | Lepidoptera larvae, including Tobacco cutworm, Diamondback moth and Rice leaf folders. | | |
| **Main Mixture Partners:** abamectin, thiacloprid | | | | | |
| **Recent History:**  At the time of its introduction, flubendiamide represented a new class of insecticide chemistry featuring the same mode of action as chlorantraniliprole, providing long lasting activity against a broad spectrum of lepidopteran pests, particularly at larval stages. Globally co-developed by Nihon Nohyaku and Bayer. The initial focus was on fruit & vegetable crops, although usage on soybean is now more significant. Launched in 2007 by Nihon Nohyaku as Phoenix in Japan and as Takumi in Thailand. Bayer has introduced the product as Belt, Fenos and Fame in the USA, the EU, Canada, Australia, Brazil and Argentina. Granted regulatory approval in India in 2007 as Fame, where it is sold by Rallis. Also approved in the Philippines, Chile (as Fenos) and Pakistan (as Belt). Well suited for use in Integrated Pest Management and Insecticide Resistance Management programmes. In 2011 Nippon Soda received registration for the product as Nisso Phoenix Flowable in Japan. Has received approval in the EU. Insecticides India entered an agreement during 2016 whereby the company introduced Nihon Nohyaku’s Suzuka in India. Registration in the USA has been cancelled, however sales of existing stocks is still permitted. | | | | | |

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| **Flubrocythrinate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Shanghai Zhong-Xi | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 30 – 100 |
| **Main Crops** | **Main Pests** | | |
| F&V | Broad spectrum insecticide with some miticidal activity | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyrethroid developed in China by Shanghai Zhong-Xi Pharmaceutical with a broad spectrum of activity. Currently used on fruit & vegetables, although has potential on many crops. | | | | | |

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| **Flucarbazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS | 80 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Everest) | None | | |
| **Application** | **Timing:** | Pre-planting, Post-emergence, | **Rate – (g/ha):** 20-30 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grass weeds | | |
| **Main Mixture Partners :**  glyphosate, fluroxypyr | | | | | |
| **Recent History:**  Developed by Bayer and launched in Canada in 2000, and in the USA and Latin America (as Vulcano) in 2001. Recommended for the control of wild oats (*Avena fatua*) and green foxtails (*Setaria viridis*), the product is used in tank mixtures with other herbicides along with a surfactant for broad-spectrum weed control. Global rights to the product were divested to Arysta for anti-trust reasons following Bayer’s acquisition of Aventis. Fits well with the major wheat weeds encountered in the USA and has been well received in the wild oat control sector.  Pre-Pare, a water dispersible granular formulation, was introduced in the USA in 2008 for burndown pre-planting use on winter and spring wheat. Pre-Pare can also be combined with glyphosate in a pre-plant, pre-emergence or post-emergence application to provide contact and residual soil activity. Mixture products with fluroxypyr (Everest, Raze) have also been introduced. In 2011 a new formulation, Everest 2.0, was introduced, featuring a safener for use on spring and durum wheat, and for the control of Japanese brome. Everest 2.0 has also received approvals for use with additional tank-mix partners; a registration for use on winter wheat; and approval for aerial applications.  Through a 2010 agreement, Arysta supply Syngenta with the product, which is marketed by Syngenta as Sierra for use on wheat in the USA. Arysta’s Indian subsidiary Devidayal market Everest in India, whilst the product has also been launched in South Africa and Argentina, with the product being distributed by Insuagro in Argentina. Everest WDG was launched by Arysta in Russia and Pakistan in 2014 for use on wheat. Currently under re-evaluation in Canada. | | | | | |

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| **Flucetosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Sulfonylurea | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| LG Chemical (Fluxo) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 10-30 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grass and Broadleaf weeds including *Echinocloa* and *Gallium aparine* | | |
| **Main Mixture Partners:** carfentrazone-ethyl, benzobicyclon, cafenstrole | | | | | |
| **Recent History:**  Sulfonylurea developed for use on rice, cereals and turf. Highly effective against barnyard-grass weeds through both foliar and soil application. Registered in Korea in 2004. Developed by Ishihara for use in Japan, with registration received in 2009. Introduced in Japan in 2012 in a mixture with carfentrazone-ethyl as Fullcharge Sky and with cafenstrole, carfentrazone-ethyl and benzobicyclon as Full Inning Sky. Commonly found in mixture formulation products. | | | | | |

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| **Flucythrinate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 1981 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Pay-off) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-50 |
| **Main Crops** | **Main Pests** | | |
| F&V | Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum pyrethroid that has never progressed to being a significant product in the sector. Became part of BASF following the Cyanamid acquisition. Agro-Kanesho acquired BASF’s global flucythrinate business in 2014. Not re-registered in the EU. | | | | | |

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| **Fludioxonil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Pyrrole | 280 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Sapphire, Maxim) | None | | |
| **Application** | **Timing:** | Seed treatment, Foliar | **Rate – (g/ha):** 250-500 |
| **Main Crops** | **Main Pests** | | |
| Maize | Seedling blight, Damping off | | |
| Vine | *Botrytis* | | |
| Cereals | Bunt, *Fusarium* | | |
| F&V | A wide range of diseases | | |
| Soybean | Aerial blight, Frogeye leaf spot, Pod and Stem blight | | |
| **Main Mixture Partners :** metalaxyl-m, cyprodinil, thiamethoxam, sedaxane, difenoconazole | | | | | |
| **Recent History:**  Phenylpyrrole product, initially introduced as a seed treatment in the cereals sector, although it also has foliar uses. Benefited from replacing fenpiclonil which was introduced in 1988 as Beret, but was not re-registered. Has a broad spectrum of activity against cereal diseases, being active against *Rhizoctonia*, *Helminthosporium* and *Septoria*, as well as possessing activity against a wide range of diseases of vine, fruit, vegetables, turf and ornamentals, including *Botrytis*, *Monilia* and *Alternaria*. Also used in many mixtures, predominantly in the seed treatment sector and notably in Syngenta’s Cruiser Maxx range, with metalaxyl-m, cyprodinil, difenoconazole, thiamethoxam, and more recently sedaxane. CruiserMaxx Vibrance gained US registration for use on seed potato in 2017. Now subject to generic competition, notably from Nufarm, who gained registration for the product in the USA in 2012 as Spirato for use on a variety of crops. Has received Annex 1 approval in the EU. Syngenta launched Visivio for use on canola in Canada in 2016 and Vibrance Duo for use on cereals in the UK in 2017. | | | | | |

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| **Fluensulfone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other – Nematicide | <10 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Nimitz) | None | | |
| **Application** | **Timing:** | Contact | **Rate – (g/ha):** 2000-4000 |
| **Crops** | **Main Pests** | | |
| F&V, Potato | Nematodes | | |
| **Recent History:**  Developed by Adama as MCW-2. Heterocyclic fluoroalkenyl sulfone active through reduced locomotion/paralysis, cessation of feeding and egg development (reducing laying, hatching and development as well as the viability of eggs). Received US registration in 2014 and approved in Israel in 2015. In 2015 Adama opened a new manufacturing facility for the product in Neot Hovav, Israel. Currently under registration review in Brazil. Gained approval for use in Mexico, Australia and the USA in 2015, followed by usage extensions to cover a range of further crops in the USA in 2016. In 2017 Adama received approval for use on fruit and vegetables in Japan, South Korea and Taiwan and are currently seeking approval in Canada. | | | | | |

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| **Flufenacet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 250 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Axiom, Fosburi, Herold) | None | | |
| **Application** | **Timing:** | Ppi, Pre- and Post-emergence | **Rate – (g/ha):** 450-900 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Grasses and some broadleaved weeds | | |
| **Main Mixture Partners :**  acetochlor, foramsulfuron, metosulam, metribuzin, diflufenican, oxyfluorfen, pendimethalin, atrazine, flurtamone | | | | | |
| **Recent History:**  Oxyacetamide (triazolopyrimidine) herbicide developed for use in mixtures for grass weed control with a wide time window for application. Main market is in cereals, with registrations achieved both alone and in mixtures, including a co-formulation with diflufenican as Herold, although the rights to Herold in Germany were divested to MAI following the acquisition of Aventis. Also offered in co-formulations, with acetochlor and metosulam as Terano; with metribuzin as Axiom and Fedor; and with metribuzin and atrazine as Axiom AT. In 2010 Bayer launched Bacara Forte (flufenacet, flurtamone and diflufenican) for use on cereals in Chile, the product designed to combat resistance on weeds such as ryegrass and foxtail. Has received Annex 1 approval in the EU, with approval extended to the end of October 2018. A mixture with diflufenican, Liberator G, was approved in Japan in 2014 for use on cereals. | | | | | |

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| **Flufenoxuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | <30 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Cascade) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 20-40 |
| **Main Crops** | **Main Pests** | | |
| Vine | Caterpillars, Leaf rollers | | |
| F&V, Pome fruit, Soybean | A wide range of insects and mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Insect growth regulator with acaricidal activity against a broad range of mites. Refused re-registration in the EU, although the product has since been granted biocide approval for use as a wood preservative. Sold as a combination broad spectrum insecticide product in Argentina, branded Tacazo, | | | | | |

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| **Flumetralin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <30 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Prime+) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha)**: 500-1000 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops | n.a | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Specific plant growth regulator for control of sucker growth in tobacco. Has achieved registration in the EU. Currently under review for use in the USA. | | | | | |

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| **Flumetsulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Others | 45 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Broadstrike, Preside) |  | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 70 |
| **Main Crops** | **Main Pests** | | |
| Maize, Soybean, Peanuts, Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** florasulam, s-metolachlor, acetochlor, clopyralid | | | | | |
| **Recent History:**  Sulfonamide broadleaved weed herbicide used in many mixtures on maize (post-emergence) and soybeans (pre-emergence residual treatment). Introduced to the market at a very competitive time, and steadily gained sales despite the impact of herbicide tolerant crops. SureStart, a mixture with acetochlor and clopyralid, received US EPA approval in 2007 for early season control of grasses and broadleaved weeds on Roundup Ready maize prior to later season applications of glyphosate and has achieved significant commercial success. Registration in some countries has been extended to other crop sectors. Also sold in a mixture with florasulam on cereals. In 2010 Monsanto added the product to its portfolio in a mixture with acetochlor and clopyralid as TripleFlex. | | | | | |

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| **Flumiclorac-pentyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Resource) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 30 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Cotton | Broadleaved weeds | | |
| **Main Mixture Partners :** lactofen | | | | | |
| **Recent History:**  Phthalimide contact herbicide for broadleaved weed control. Has never made any significant commercial impact. Also sold in a mixture with lactofen as Stellar for soybean use in the USA and marketed by Valent. | | | | | |

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| **Flumioxazin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | 350 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Sumisoya, Flumyzin) | None | | |
| **Application** | **Timing:** | Burndown, Pre-emergence, post-emergence | **Rate – (g/ha):** 50-100 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Peanuts, Sugarcane, Cotton, Cereals, Maize, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diuron, cloransulam, thifensulfuron, chlorimuron, pyroxasulfone, tribenuron | | | | | |
| **Recent History:**  Phthalimide herbicide for pre- and post-emergence control of annual broadleaved and some grass weeds. Initially introduced for use on soybeans but now finds usage on many other crops, including for the control of glyphosate resistant weeds on cotton and soybeans in the USA. Launched by Sumitomo Chemical in Japan in 1993, it is now sold in most major markets around the world. Has received approval in the EU. BASF markets the product in France for use on vines as Pledge, with Sumitomo’s subsidiary Kenogard marketing Pledge in Spain. Introduced in Germany in 2006 for use on cereals, followed by the UK and Ireland in 2007. Marketed by Valent in the USA for use on soybeans and peanuts, as well as in combination with Kumiai’s pyroxasulfone as Fierce which was approved for use on corn in 2012 and soybeans in 2013. In Japan the product is sold as a pre-mix with glufosinate for orchard and non-crop use as Groundboy. DuPont has access to the product to create combination herbicides for soybeans, with mixtures with thifensulfuron and chlorimuron (Enlite, Envive), and with thifensulfuron and tribenuron (Afforia) since being introduced. Monsanto has also gained access to the product, introducing Valor SX, Valor XLT and Gangster, with Sumitomo’s flumioxazin also being included on the Roundup Ready Plus program. Valent received Canadian approval in 2009 for use on soybeans as Valtera, and in 2011 entered an agreement for Nufarm to assume sales of the product in Canada. Sumitomo expanded its production capacity for the product at its Oita facility in Japan in 2012. Nufarm introduced Panther SC to the USA in 2015 for use on maize, soybean, cotton, peanut and other crops, and Panther Pro in 2017. | | | | | |

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| **Flumorph** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | <10 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sinochem / Shenyang Research (Mike, Fostar) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 100-200 |
| **Main Crops** | **Main Pests** | | |
| F&V | Oomycete diseases | | |
| **Main Mixture Partners :** fosetyl | | | | | |
| **Recent History:**  Analogue of dimethomorph which has been introduced in China. | | | | | |

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| **Fluometuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Cotoran) | IPiCi | | |
| **Application** | **Timing:** | Pre-emergence, post-emergence | **Rate – (g/ha):** 1000-3500 |
| **Main Crops** | **Main Pests** | | |
| Cotton | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  At one time, amongst the leading urea herbicides and a major cotton product, providing pre- and post-emergence control of a range of grasses and broadleaved weeds. Adama acquired the rights to the product in the USA from Novartis in 1999 and the Cotoran business from DuPont in 2007. In 2010 Cotoran was added to Monsanto’s Roundup Ready Plus program. Has gained re-registration in the EU. | | | | | |

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| **Fluopicolide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other (Acylpicolide) | 45 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Infinito, Profiler) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 70-100 |
| **Main Crops** | **Main Pests** | | |
| Potato, Vine, F&V | Oomycete diseases, downy mildew | | |
| **Main Mixture Partners:** propamocarb, fosetyl, propineb | | | | | |
| **Recent History:**  Offers a novel mode of action against a wide range of oomycete diseases in vine, potatoes and vegetables, as well as turf and ornamentals. Received its first approvals in China, South Korea and the UK in 2006 as Infinito, a mixture with propamocarb for use on potatoes and vegetables. This was followed by approvals in Poland, Austria and Germany in 2007, Chile and Belgium in 2008, Italy and Brazil in 2009 and Peru in 2010. Has achieved Annex 1 registration in the EU and a recent extension takes approval to 2023. Profiler, a combination with fosetyl, is used on vine and was launched in Portugal in 2011. Portuguese authorities also approved the product in a mixture with propamocarb as Volare. Marketed as Reliable in Japan where it gained approval in 2008 for use on potatoes. Sumitomo’s subsidiary Valent holds the marketing and development rights in the USA and Canada, with the product receiving US approvals in 2008, as Stellar for use on turf & ornamentals and as Presidio for use on vine and vegetable crops. Bayer launched the product in 2011 in Peru in a mixture with propineb as Trivia for use on potatoes, and in 2012 launched Infinito (fluopicolide and propamocarb) in Colombia for use on palm. In 2016 Infinito gained extension in Brazil for use on additional fruit and vegetable crops. Approval proposed for Infinito in 2017 in Australia for vegetables and potatoes. | | | | | |

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| **Fluopyram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide, Nematicide | | SDHI | 65 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Luna) |  | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 200-250 |
| **Crops** | **Main Pests** | | |
| Vine | Powdery mildew, *Botrytis* | | |
| Potato | *Alternaria solani* (early blight), nematodes | | |
| Rape, Peanut, F&V | A wide range of diseases | | |
| **Main Mixture Partners:** prothioconazole, tebuconazole, pyrimethanil, trifloxystrobin | | | | | |
| **Recent History:**  Pyridinyl ethyl benzamide fungicide active through the inhibition of succinate dehydrogenase. Member of a new chemical class offering reduced application rates, primarily targeted at speciality and industrial crops. Reportedly improves storability and increases the shelf life of harvested produce. US EPA approval achieved in 2012. Has also received approval in the EU. Introduced in the UK in 2012 as Raxil Star, a seed treatment mixture with prothioconazole and tebuconazole for use on barley. Luna Experience, a mixture with tebuconazole, has been introduced in Turkey, Chile and Mexico for use on fruit crops. Introduced in Canada in 2013 in combination with pyrimethanil as Luna Tranquility for use on apples and wine grapes and in Italy as Luna Privilege for use on vines. In addition, the product has also been introduced in Honduras and Costa Rice as Verango, a suspension concentration formulation for use as a nematicide on bananas. In 2014 Bayer received approval for ILeVO, reportedly the first seed treatment to provide protection for soybean seedlings from the soil borne pathogen *Fusarium virguliforme*, the fungus which causes Sudden Death Syndrome. In 2016 Bayer received US approval for Indemnify and Velum Prime, as well as for Exteris Stressgard, a mixture with trifloxystrobin. Copeo Prime seed treatment was launched in the US in 2016. | | | | | |

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| **Fluoxastrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 180 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Fandango) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** 1250-1500 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Coffee, Turf | Septoria, Fusarium, Rhyncosporium, mildew, net blotch, rust | | |
| **Main Mixture Partners :** prothioconazole, tebuconazole, fluoxastrobin, flutriafol | | | | | |
| **Recent History:**  Strobilurin fungicide with curative, leaf-systemic activity particularly against diseases of barley, now finding increasing usage in the seed treatment sector. Introduced in the UK in 2004 as Fandango, a combination with prothioconazole. Has also been approved in a number of other European countries and has received EU Annex 1 approval. Has also been introduced as Vigold for use on potatoes and tomatoes, and as Vigold-T with tebuconazole. The seed treatment Scenic, a combination of fluoxastrobin, prothioconazole and tebuconazole, was introduced in Argentina in 2011.  Arysta has exclusive international access to the product for all crop and non-crop applications, except seed treatment use and in proprietary Bayer mixtures. The company has introduced the product in the USA for use on potatoes, fruit & vegetables, sweet corn and wheat as Evito and on turf as Disarm, with FMC marketing Disarm for use on turf and ornamentals. Evito has also been introduced in Canada for a range of crops. Arysta and Cheminova (now part of FMC) have introduced Fortix, a combination with flutriaol, in the USA for use on corn, wheat and soybeans. Evito T, which also contains tebuconazole, was launched by Arysta in Zambia and Mozambique in 2013 for use on maize, soybeans, sugarcane, wheat and other crops, and in Ukraine in 2016 for use on cereals and oilseed rape. Arysta’s Zolera FX (a mixture with tetraconazole) was launched in the USA in 2015 for use on maize and soybeans. Approved in China for use in tomatoes and cucumbers in 2017. | | | | | |

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| **Flupoxam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <30 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kureha (Ovation) | None | | |
| **Application** | **Timing:** | Pre-emergence,  Post-emergence | **Rate – (g/ha):** 175 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Minor triazole herbicide for pre- and early post-emergence control of broadleaf weeds in cereals, including *Galium aparine, Veronica* spp., and *Stellaria media*. Jointly developed by Monsanto and Kureha. Not re-registered in the EU. Introduced by Nippon Soda in Japan as Conclude for use on turf in 2009. | | | | | |

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| **Flupyradifurone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other - Butenolide | <10 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Sivanto) |  | | |
| **Application** | **Timing:** | Foliar, Soil, Seed | **Rate – (g/ha):** 50-200 |
| **Crops** | **Main Pests** | | |
| Top fruit, Vegetables, Cotton, Soybean, ornamental, lawn | Sucking insects (aphids, leafhoppers, whiteflies, scales) | | |
| **Recent History:**  Sucking pest insecticide from a new class of insecticide chemistry, butenolides, reported to have no effect on the development of honey bee colonies. Developed by Bayer as BAY102960. As it is highly selective, with no impact to most beneficials in fruit & vegetable crops, Sivanto is intended for use in Integrated Pest Management programs together with biologicals and beneficials. Controls major sucking pests such as aphids, whiteflies, hoppers, psyllids and others, and is reportedly effective at all mobile stages including larvae and adults. The product is targeted for use on pome fruits, citrus, potatoes, tomatoes, melons and cotton. Application rate depends on crop and canopy height. Bayer launched Sivanto Prime in Honduras, Guatemala and the Dominican Republic in 2014. Also approved in the USA, Mexico and Canada for use on various crops, including F&V and soybeans. Gained registration for use in the EU with current approval expiring in December 2025. Bayer launched Altus as an ornamental, lawn and landscape insecticide in 2017. | | | | | |

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| **Flupyrsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Lexus) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 10 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grass weeds | | |
| **Main Mixture Partners :** metsulfuron-methyl, carfentrazone-ethyl, thifensulfuron, pyroxsulam, diflufenican, pyroxsulam | | | | | |
| **Recent History:**  One of the later sulfonylureas introduced for use on cereals, with particular activity against resistant blackgrass. Weed coverage is expanded by combination with FMC's carfentrazone-ethyl as Lexus Class, a treatment that was initially well received in the EU cereal herbicide market as a DFF/isoproturon replacement; however other mixtures are now more significant, notably with metsulfuron (as Lexus XPE) and thifensulfuron (Lexus Millennium). Major usage is in the control of resistant blackgrass, particularly following a pre-emergence triallate treatment. EU member states were instructed to withdraw approvals by December 2017, with a grace period up to December 2018 to use existing stocks. In 2017 DuPont agreed to divest flupyrsulfuron-methyl to FMC as part of the regulatory conditions required for the merger approval between Dow and DuPont. | | | | | |

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| **Fluquinconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 50 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Castellan, Flamenco, Galmano) | Bayer | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals, Soybean | Brown rust, Net blotch, *Septoria* leaf spot, Yellow rust, Powdery mildew (*Funicular and Photosphere*) | | |
| **Main Mixture Partners :** chlorothalonil, pyrimethanil, prochloraz | | | | | |
| **Recent History:**  Triazole fungicide which was first introduced for use on cereals. Rights to the product in Europe and seed treatment uses worldwide were divested to BASF by Bayer following the acquisition of Aventis. Introduced as a seed treatment for the control of Take-all in a mixture with prochloraz as Jockey in the UK in 2001. Registered as Atento in Brazil in 2007 for use against soybean rust. Has received re-registration in the EU. | | | | | |

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| **Fluridone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | <10 | 1981 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| SePRO (Sonar) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 550-2250 |
| **Main Crops** | **Main Pests** | | |
| Non-crop | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyridinone herbicide for the control of weeds in ponds, drainage ditches and canals. Active on growing weeds. Originally developed by Dow, SePRO subsequently acquired Dow’s position in the product in 1994. SePRO followed this in 2012 with the purchase of Tessenderlo Kerley’s aquatic herbicide business, including registrations, trade names and other related assets for fluridone. Not re-registered in the EU. | | | | | |

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| **Flurochloridone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 35 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Racer) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 750 |
| **Main Crops** | **Main Pests** | | |
| Sunflower, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** acetochlor, trifluralin | | | | | |
| **Recent History:**  Broad–spectrum product finding the majority of its sales in secondary herbicide markets, particularly sunflower. Divested by Syngenta to Adama in 2002. Mainly used in Europe and Argentina. One of the leaders of the sunflower herbicide sector. Has received EU approval. | | | | | |

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| **Fluroxypyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 255 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Starane, Tomahawk) | Adama, Rainbow Chemical | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100-400 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Broadleaved weeds, Grasses | | |
| **Main Mixture Partners :**  clopyralid, MCPA, dicamba, metsulfuron, 2,4-D, florasulam, triclopyr, picloram, flucarbazone, pinoxaden, thiencarbazone, tribenuron, thifensulfuron, halauxifen | | | | | |
| **Recent History:**  Introduced specifically for the control of *Galium aparine* (cleavers) in cereals, benefiting from activity against all stages of weed growth. *Galium* control is a particular problem in European cereals, and is of lesser importance in maize and oilseed rape. Often used in premixes with broad-spectrum cereal herbicides. Has achieved Annex 1 re-registration in the EU with approval for use until the end of December 2021. A mixture product with florasulam (as Kart in France) has been positioned to replace the stand-alone fluroxypyr products. Has been introduced in the US for use on a range of crops, including maize, potatoes and non-crop land, and also in a combination with dicamba as Pulsar for use on cereals. Several mixture products have been introduced, including notably with florasulam from Dow (UK); thifensulfuron and tribenuron and also flucarbazone by Arysta (USA); and pinoxaden by Syngenta (US and Canada). In 2014 the Chinese company Rainbow Chemical received registration for the product in South Africa. Several new combination products were introduced in Canada for use on cereals in 2015, including Outshine (with florasulam) and Rush M (with MCPA ester) from Adama; Predicade (with thiencarbazone, tribenuron, thifensulfuron and MCPA) and Travallas (with metsulfuron-methyl and thifensulfuron-methyl) from DuPont; and TraxosTwo (with pinoxaden, clodinafop and 2,4-D) from Syngenta. Introduced in Denmark and the UK as Pixxaro (also containing halauxifen) in 2016. Dow’s DHT system, which provides tolerance to 2,4-D and auxin herbicides such as fluroxypyr & triclopyr, was licensed to DuPont for use in soybeans. Innvictis launched Stave for control of annuals/perennials in wheat/barley in 2017 in the US. Dow launched Zypar in the UK for broadleaf weed control in 2017. | | | | | |

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| **Flurtamone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Benchmark, Bacara, Carat, Ingot) | None | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence,  Post-emergence | **Rate – (g/ha):** 250-500 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sunflower | Broadleaved weeds | | |
| **Main Mixture Partners :** diflufenican, aclonifen, flufenacet | | | | | |
| **Recent History:**  Broadleaved weed herbicide only sold in mixtures. The major usage is on cereals with diflufenican (as Bacara, Carat and Dolmen) and with isoproturon and diflufenican as Bizon. In 2010 Bayer introduced the product in Chile in a mixture with flufenacet and diflufenican as Bacara Forte for use on cereals. Secondary usage is on sunflower, peas and beans in a mixture with aclonifen as Cline and Nikeyl. Potential also exists for introduction in peanuts and cotton. Has received extension to EU approval until October 2018. | | | | | |

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| **Flusilazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 45 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Punch, Nustar) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 70-200 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Brown rust, Leaf blotch, *Septoria* leaf spot, Yellow rust | | |
| F&V, Plantation crops, Sugarbeet | A wide range of diseases | | |
| **Main Mixture Partners :** famoxadone, carbendazim, fenpropimorph | | | | | |
| **Recent History:**  Broad-spectrum second-generation triazole fungicide, mainly used on cereals in Europe. Received rapid market acceptance post introduction, but sales subsequently suffered from the introduction of third-generation triazole products. Has not achieved EU re-registration. | | | | | |

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| **Flusulfamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Nebijin) | None | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V | Damping off and a range of vegetable diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pre-plant incorporated fungicide for the control of soil borne diseases in brassicas and sugarbeet, particularly for control of the vector for rhizomania disease. Mainly used in Japan and South Korea, the product has not been registered in the EU. Mitsui has had a distribution tie-up with Indonesian based Agricon since the launch of Nebijin (flusulfamide) product in 2009. This marketing arrangement was strengthened in 2017 when Mitsui acquired outstanding shares in the Agricon subsidiary that sells Mitsui products. | | | | | |

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| **Fluthiacet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Herbicide/PGR | <30 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC  (Action, Appeal, Cadet) | Arysta LifeScience | | |
| **Application** | **Timing:** | Pre-planting, Post-emergence | **Rate – (g/ha):** 2.5-5 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Maize | Broadleaved weeds | | |
| Cotton | Defoliation | | |  | |
| **Main Mixture Partners :** pyroxasulfone, atrazine, fomesafen, mesotrione | | | | | |
| **Recent History:**  Developed by Kumiai in collaboration with Syngenta, and now introduced as a cotton defoliant in the USA. Chemtura (now Arysta LifeScience) introduced the cotton defoliant product Blizzard into the US market in 2007. FMC acquired sole marketing rights to the product in the US maize and soybean markets as Cadet in 2008, followed by full rights to the product from Kumiai / Ihara in 2010, with Chemtura retaining the rights to Blizzard. FMC also has the right to market the product in mixtures with pyroxasulfone for maize, wheat and soybeans in Mexico, the USA and Canada, with Anthem ATZ (pyroxasulfone, fluthiacet-methyl and atrazine) introduced for use on maize in the USA in 2013. Also in 2013, FMC launched Marvel, which contains fluthiacet and fomesafen, for use on soybeans. This was followed in 2014 by the launch of Solstice, which also contains mesotrione, for use on maize in the USA. In 2017 Etec Solutions gained approval in New Zealand for Cadet, a product for use on maize crops. | | | | | |

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| **Flutianil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Thiazolidine | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (Pinpoint) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 20-70 |
| **Crops** | **Main Pests** | | |
| F&V, Ornamentals | Powdery mildew | | |
| **Recent History:**  Developed as OK-5203. Active through the inhibition of mycelium growth. Also being developed by Valent as Pinpoint. Currently under review for use in the USA. | | | | | |

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| **Flutolanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | <30 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Applaud, Moncut) | Bayer | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 225-600 |
| **Main Crops** | **Main Pests** | | |
| Rice | Sheath blight | | |
| Potato | Black scurf | | |
| F&V, Peanuts, Turf, Ornamentals | A range of diseases | | |
| **Main Mixture Partners :** mancozeb, buprofezin | | | | | |
| **Recent History:**  Mature Sheath blight *(Rhizoctonia solani)* fungicide, also with activity against black scurf on potatoes. Developed for use as a potato seed treatment by Aventis who marketed the product as Iota in France, and as Oscar in a mixture with mancozeb. Now part of Bayer, who have introduced the product for turf and ornamental uses in the USA as Prostar. Marketing rights in France passed to Philagro following the acquisition of Aventis. Certis have introduced the product as a potato seed treatment in the UK as RhiNo for the control of *Rhizoctonia*. Re-registration in the EU has been achieved with approval for use until the end of February 2019. | | | | | |

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| **Flutriafol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 70 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Impact, Vincit) | None | | |
| **Application** | **Timing:** | Foliar, Soil, Seed treatment | **Rate – (g/ha):** 30-125 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Yellow rust, Brown rust, *Septoria tritici* | | |
| Soybean | Asian Rust, Brown spot, Leaf blight, Frogeye leaf spot, Powdery mildew | | |
| F&V | A wide range of diseases | | |
| **Main Mixture Partners :** carbendazim, maneb, triadimefon, azoxystrobin, fluoxastrobin | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide for cereal disease control predominantly used in mixtures. Also with some usage as a seed treatment for early season control of *Septoria* and rusts. Subsequently superseded by new generation triazoles and affected by the success of the strobilurins. The product was acquired by Cheminova in 2001 from Syngenta and gained significant sales in the Asian soybean rust market in Brazil. Has been re-registered in the EU with use approved until the end of May 2021. Introduced as Topguard in the USA for use on soybeans, apples and cotton and was upgraded to Topguard EQ in 2017 for use on more than 20 crops. Authority, a mixture with azoxystrobin, has been introduced in Brazil for use on wheat, soybean and cotton. In 2013 Cheminova and Arysta received US approval for Fortix, which contains flutriafol and fluoxastrobin, for use on corn and rotational crops such as peanuts, sugarcane and cotton. FMC obtained the product through the acquisition of Cheminova in 2015. | | | | | |

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| **Fluvalinate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <30 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Mavrik) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 70-175 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V, Pome fruit, Plantation crops | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum pyrethroid now sold in the partially resolved tau form. Acquired by Adama on the formation of Syngenta and has been re-registered in the EU and the USA. | | | | | |

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| **Fluxapyroxad** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 410 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Priaxor, Adexar, Xemium) |  | | |
| **Application** | **Timing:** | Foliar, Seed Treatment | **Rate – (g/ha):** 100-200 |
| **Crops** | **Main Pests** | | |
| Cereals, Soybean, Speciality crops, Turf | Broad spectrum | | |
| **Main Mixture Partners:** epoxiconazole, pyraclostrobin, metalaxyl, tetraconazole | | | | | |
| **Recent History:**  Active through the inhibition of succinate dehydrogenase, effective against major diseases in various crops, offering both preventative and curative control. Has received registration in the EU with approval until the end of December 2022. Approved in the UK, France and Germany in 2011 as Adexar, a mixture with epoxiconazole for use on cereals. Has also been introduced in a number of mixtures with pyraclostrobin, including Orkestra in Brazil, primarily for the control of Asian soybean rust; Lexicon Intrinsic for turf in the USA; and Priaxor in Canada, Argentina and other country markets. Other uses include as Sercadis in the USA for the control of sheath blight in rice. BASF supply Monsanto with fluxapyroxad for use in Monsanto’s Acceleron seed treatment range for soybeans and cotton. BASF recently invested in an expansion of its formulation capabilities for the product at its facility in Guaratinguetá, Brazil. Recent combination product introductions in the USA include the seed treatment Obvius (with metalaxyl and pyraclostrobin) for use on pulses, podded vegetables and canola in USA; and Priaxor D (with pyraclostrobin and tetraconazole) for the control of strobilurin-resistant frogeye leaf spot on soybeans. In 2016 BASF introduced Insure Pulse (fluxapyroxad, pyraclostrobin and metalaxyl) in Canada, and gained US EPA approval for Systiva XS to control certain soil borne diseases on sugarbeet, including Rhizoctonia. Branded fluxapyroxad products for use on cereals were launched in Spain, South Africa and India in 2017. | | | | | |

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| **Folpet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Phthalimide | 70 | 1955 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Folpan) | Various | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 1000-2500 |
| **Main Crops** | **Main Pests** | | |
| Vine | Downy mildew | | |
| F&V, Cereals | A wide range of diseases | | |
| **Main Mixture Partners :**  fosetyl-al, metalaxyl-m, triadimenol, copper-oxychloride, pyraclostrobin, cymoxanil, dimethomorph, azoxystrobin | | | | | |
| **Recent History:**  Commodity phthalimide fungicide active against most of the important diseases of fruit and vegetables, including downy and powdery mildew and *Botrytis*. Not registered in the US, but accepted for re-registration in the EU. Major market is on vines where it is used in many mixtures, notably with fosetyl-al and cymoxanil. In 2016 Phoenix (folpet) was launched in New Zealand for use on wheat and barley. | | | | | |

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| **Fomesafen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | 180 | 1982 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Flex) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 210-420 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Cotton | Broadleaved weeds | | |
| **Main Mixture Partners :** bentazone, imazethapyr, metolachlor, glyphosate | | | | | |
| **Recent History:**  Diphenyl ether herbicide for post-emergence broadleaf weed control in soybeans which now also finds usage on vegetables. Sales have been affected by the uptake of Roundup Ready soybeans, although the product has recently benefitted from use to clear up glyphosate tolerant weeds. Not re-registered in the EU and left that market in 2003. Flexstar was added to Monsanto’s Roundup Ready Plus platform in 2012 for use on soybeans in the Mid-South regions of the USA. BASF voluntarily cancelled the US registrations of Faster (fomesafen and bentazone) in 2009. In 2013 Adama introduced three new formulations in the USA: Rumble, Torment (both with imazethapyr), and Vise (with metolachlor). Cheminova, now part of FMC, launched Statement, also containing metolachlor, in the USA in 2014 for pre-plant and pre-emergence use on soybeans, and for tank-mixes with other herbicides on cotton. Monsanto has developed Warrant Ultra, a microencapsulation formulation of acetochlor and fomesafen, for use on soybeans and cotton. | | | | | |

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| **Foramsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 115 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Fortuna, MaisTer, Equip) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 40 |
| **Main Crops** | **Main Pests** | | |
| Maize, Turf | Grass and Broadleaf weeds | | |
| **Main Mixture Partners :**  sulcotrione, flufenacet, metosulam, iodosulfuron, terbuthylazine, thiencarbazone-methyl, halosulfuron | | | | | |
| **Recent History:**  Developed by Aventis and now part of the Bayer portfolio. Introduced in Romania and Turkey in 2001, and approved in the USA, where it has been introduced as Revolver for turf and as Option for maize, and the EU in 2002. Used in many combination products, including with iodosulfuron and the safener isoxadifen. Recently introduced mixture products include Tribute Total (with thiencarbazone-methyl and halosulfuron-methyl) for use on turf in the USA and as Monsoon Active (with thiencarbazone-methyl and cyprosulfamide safener) for use on maize in Portugal and Spain. Has EU approval until July 2018. | | | | | |

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| **Forchlorfenuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kim-Ci / Valent / Deg (Prestige) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice, Vine, F&V |  | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Niche product used to enhance fruit size. First introduced by Degussa in Europe in 2005 and then in China in 2006. Valent has exclusive development and marketing rights in the USA, launching the product in the country in 2005 for table grapes and kiwi fruit. Has received full Annex 1 registration in the EU, where it was supported by SKW Trostberg and Kyowa Hakko. Launched in Spain in 2007 as Sitofex for use on table grapes and kiwi fruit, the first EU country-level approval for the product. In 2017 Sumitomo Chemical agreed to buy the plant growth regulator business of Kyowa Hakko Bio, which includes among its top brands Fulmet (forchlorfenuron). | | | | | |

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| **Formetanate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Carzol) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-1000 |
| **Main Crops** | **Main Pests** | | |
| F&V | Insects, Mites, Thrips, Leaf miner, Stink bugs, Leaf hoppers | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum insecticide/miticide used on a wide range of crops; however, the product is of limited commercial importance. Divested by Aventis to Gowan in 2000. Has achieved re-registration in the EU with use extended until the end of July 2018. | | | | | |

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| **Fosetyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 145 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Aliette) | Chimiberg | | |
| **Application** | **Timing:** | Foliar, Soil applied | **Rate – (g/ha):** 2400-16000 |
| **Main Crops** | **Main Pests** | | |
| Vine | Downy mildew, Excoriosis | | |
| F&V, Plantation crops | A wide range of diseases | | |
| **Main Mixture Partners :**  folpet, mancozeb, fenamidone, copper-oxychloride, cymoxanil, fluopicolide, metiram | | | | | |
| **Recent History:**  Broad-spectrum systemic organophosphate fungicide with both curative and preventative activity against a wide range of diseases. Major use is on vines for downy mildew control, although it also has applications in a range of fruit and vegetable crops. Now subject to significant competition from new product introductions in the oomycete disease control sector, although a lower price and limited resistance development has helped to sustain sales. Also marketed in a variety of mixture formulations. Has received Annex 1 approval in the EU with use currently approved until the end of April 2018. Sapec Agro has launched its systemic fungicide, Maestro 80 (fosetyl-aluminium), in Portugal in 2017, primarily for use on citrus and suitable for apple and pear also. | | | | | |

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| **Fosthiazate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 65 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Nemathorin) | Syngenta | | |
| **Application** | **Timing:** | Pre-plant incorporation, Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops, Potato | Nematodes, Aphids, Thrips | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorus nematicide, mainly used on banana, tomato, vegetables, potatoes and peanuts, the product being positioned as a methyl bromide replacement. Syngenta has the distribution rights to the product outside of the Asia Pacific region, introducing the product in the UK, South Africa, Hungary, France, Italy, the USA, Latin America and the Netherlands. Has achieved an extension to the EU approval period extended until the end of October 2018. Chinese authorities approved manufacturing of the product in 2016. ISK is seeking approval in Australia. | | | | | |

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| **Fuberidazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Benzimidazole | <10 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Voronit) | None | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals | *Fusarium* spp. | | |
| **Main Mixture Partners :** imazaquin, triadimenol, bitertanol | | | | | |
| **Recent History:**  Benzimidazole fungicide used exclusively as a seed treatment offering specific control of *Fusarium*. The product is only sold in mixtures to broaden its spectrum of disease control (notably with triadimenol as Baytan, and bitertanol as Sibutol). Re-registration in the EU has been achieved with use approved until the end of February 2019. | | | | | |

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| **Furametpyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Limber) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 300-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Sheath blight | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Sheath blight (*Rhizoctonia* spp.) fungicide for use on rice introduced by Sumitomo in Japan in 1997 and subsequently in other East Asian markets, although the a.i. has never made a significant commercial impact. | | | | | |

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| **Gamma-cyhalothrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 70 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Nexide, Proaxis, Prolex) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Soybean, Maize, F&V, wheat, barley | Broad Spectrum | | |
| **Main Mixture Partners :** malathion, chlorpyrifos | | | | | |
| **Recent History:**  Originally manufactured and registered by the Pytech joint venture between Cheminova and Dow AgroSciences, Cheminova acquired full control of Pytech in 2008, retaining all rights to the product. Now passed to FMC following its acquisition of Cheminova. First introduced by Cheminova in Brazil and Argentina in 2003. Now registered in many countries across a range of crops, including in the USA as Proaxis for use on fruit, vegetables and field crops; as Prolex for use on cotton, peanuts, rice, soybeans, sugarcane and non-crop areas; and as Cobalt for use on alfalfa, cotton, maize, sorghum, wheat and sunflowers. Has also been introduced in the USA in a mixture with malathion as Fyfanon Plus ULV for use on cotton. The product finds significant uses in animal health to control ticks, fleas and flies. Has achieved Annex 1 listing in the EU with approval for use until the end of March 2025. | | | | | |

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| **Gibberellic Acid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 100 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Pro-Gibb, RyzUp) | Syngenta | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V, Soybean, Vine, Pome fruit | n.a. | | |
| **Main Mixture Partners :** 2,4-D-Amine, 6-benzyladenine, cytokinin, 1-naphthylacetic acid | | | | | |
| **Recent History:**  Plant growth regulator with many applications, the major ones being for the production of seedless grapes, improving the malting quality of barley and the production of hybrid seeds. Despite its age, sales remain relatively stable. Achieved re-registration in EU until the end of August 2019, and eligible for continued registration by the Canadian PMRA. Introduced in the USA by the Sumitomo subsidiary Valent as RyzUp SmartGrass in 2012 for use on silage corn. Arysta LifeScience North America (part of Platform Specialty Products) has launched the plant growth stimulant, Rio (gibberellic acid, indole acetic acid and cytokinin), for use on various specialty and arable crops in 2017. | | | | | |

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| **Glufosinate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Amino acid | 660 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Basta, Liberty, Rely) | Nortox, Meghmani | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence,  Post-emergence | **Rate – (g/ha):** 200-750 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V, Soybean, Cotton, Cereals, Rice, Vine, Pome fruit, Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Non-selective herbicide primarily active against annual weeds, competing directly with glyphosate and paraquat. Finds usage in markets where crop safety with Roundup is an issue, such as in orchards and hedgerows. Turnover has benefited from usage on LibertyLink (glufosinate tolerant) crops, and now also finding increasing usage for the control of glyphosate resistant weeds, particularly over GM crops that contain both the LibertyLink and Roundup Ready traits. In addition to producing LibertyLink cotton and canola, Bayer has out-licensed the technology for use in soybeans and maize. Bayer has recently undertaken a series of investments to significantly expand its production capabilities for the product at its sites in the USA. Approval in the EU has recently been extended until the end of July 2018. Bayer has agreed to a deal for BASF to acquire its glufosinate herbicide subject to the planned acquisition of Monsanto and regulatory clearance. | | | | | |

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| **Glyphosate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Amino acid | 4,408 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Roundup) | FMC, Excel Crop Care, Adama, Herbex, IPiCi, Dow, Atanor, Sinon, Nortox, Meghmani, Chinese companies | | |
| **Application** | **Timing:** | Post-harvest,  Pre-plant, Pre-emergence, Post-emergence | **Rate – (g/ha):** 550-4500 |
| **Main Crops** | **Main Pests** | | |
| RR crops and burn down and ground clearance on others | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :**  imazethapyr, diuron, terbuthylazine, diflufenican, oxyfluorfen, MCPA, simazine | | | | | |
| **Recent History:**  The largest selling agrochemical on the world market which, despite significant generic competition, continues to achieve steady sales. Sales in recent years have benefited from the exploitation of new market sectors, such as usage in reduced tillage systems and on Roundup Ready crops. Monsanto has reached agreements with a number of companies to allow usage of own-label product in the USA and on Roundup Ready crops. Glyphosate is off-patent in all markets, with many companies now involved in the manufacture and supply of the product. Due to this high level of generic competition and amount of material produced in China, oversupply of generic material can result in price fluctuations, with any corresponding price erosion having a significant impact on sales. However, volume demand continues to increase year-on-year. Dow has introduced a mixture with 2,4-D as Enlist Duo for use in its Enlist Weed Control System. Scotts have a licence agreement with Monsanto to use the Roundup brand in the lawn & garden market, with this being extended recently to cover new product categories, marketing rights in new geographies and access to Monsanto’s R&D pipeline for new lawn and garden products. During 2015 Albaugh entered an agreement with Monsanto to manufacture and sell specific glyphosate formulations in the USA, Canada and Europe. | | | | | |

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| **Guazatine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Panoctine) | None | | |
| **Application** | **Timing:** | Post-harvest treatment, seed treatment | **Rate – (g/ha):** 100-300 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V, Rice | Bunt, *Fusarium*, Rice blast | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Mainly used as a seed treatment for the control of damping-off diseases and bunt (*Tilletia caries*) in cereals, offering some control of *Septoria*. Also used post-harvest on citrus and pineapples. Aventis divested the product to Adama in 2000. EU re-registration has been refused. | | | | | |

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| **Halauxifen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Arylex) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 5 |
| **Crops** | **Main Pests** | | |
| Cereals | Broadleaf weeds | | |
| **Main Mixture Partners:** aminopyralid, florasulam, fluroxypyr | | | | | |
| **Recent History:**  Picolinic acid herbicide marketed as the methyl-ester version halauxifen-methyl. Gained approval for use on cereals in Canada, Australia, EU and China and is currently under review in New Zealand. Launched in Australia in 2015 as Paradigm Arylex (with florasulam) and as ForageMax Arylex (with aminopyralid). In Dow gained approval in the UK for Pixxaro, a mixture with fluroxypyr, and in Denmark for Zypar, a mixture with florasulam. Received approval in Italy for use on cereals in 2017. | | | | | |

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| **Halfenprox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Anniverse, Danibon, Sirbon) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, F&V | Mites *(Panonychus* and *Tetranychus* species*)* | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Halogenated analogue of etofenprox (Trebon), also known by the names fubfenprox, fluproxyfen and flufenprox. Marketed in Japan for spider mite control (all stages) on citrus, vines and vegetables. Of limited commercial significance and not supported through re-registration in the EU. | | | | | |

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| **Halofenozide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other IGR | <10 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Mach 2) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Turf | Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  A moult accelerating compound (MAC), with activity against Lepidoptera, Coleoptera, Homoptera and Diptera insect species, predominantly used on turf. Developed and marketed by the Rohm & Haas joint venture with Cyanamid, RohMid, now wholly owned by Dow. Registrations in the USA were cancelled at the request of Dow in 2013. | | | | | |

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| **Halosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 45 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan (Permit, Manage, HighCut) |  | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 18-90 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Rice, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** dicamba, thiencarbazone-methyl, foramsulfuron, benzobicyclon | | | | | |
| **Recent History:**  Sulfonylurea herbicide for the control of broadleaved weeds in a number of crops. Main uses are rice in Japan and rice and sugarcane in the USA. Jointly developed with Monsanto for post-emergence use in maize, sorghum, sugarcane and turf. Has gained EU approval, and has also been approved in Canada. The product is distributed in the USA by the Canyon Group, a joint venture between Gowan and Nissan, with Gowan developing the product for a number of uses in the country including on vegetable crops and alfalfa, as well as turf and landscaped areas. Yukon, a mixture with dicamba, has also been introduced. Nissan’s European subsidiary received approval in Italy in 2008 for use on rice, the first registration in the EU. Bayer launched the product in 2012 in a mixture with thiencarbazone-methyl and foramsulfuron as Tribute Total in the USA for use on turf. Butte, (halosulfuron and benzobicyclon) was launched in the US for use on Rice in 2017. | | | | | |

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| **Haloxyfop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 155 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Verdict, Gallant) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 55-135 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Rape, Cotton, Sunflower, Potato | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Post-emergence graminicide with a wide range of applications on broadleaved crops. One of the most active graminicides, not registered in the USA, but finding significant sales in other geographies, led by Argentina and Brazil. Sales have fallen from the peak levels achieved in the mid-1990s as a result of the uptake of Roundup Ready crops, notably soybean, cotton and canola. Usage in China has increased significantly in recent years, with the main crop use in the country being oilseed rape. Haloxyfop has now largely been replaced by the resolved haloxyfop-R; haloxyfop being refused registration in the EU, with haloxyfop-R gaining re-registration. | | | | | |

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| **Harpin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Plant Health Care (Messenger) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| F&V | *Botrytis*, Bunch rot, Powdery mildew | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Developed to stimulate a plant’s natural disease defence mechanisms, based on a natural protein derived from *Erwinia amylovora*, the bacterium responsible for fire blight on pome fruit and ornamentals. The product was acquired by Plant Health Care from Eden Bioscience in 2007. Has been registered in a number of country markets, including in the USA for *Botrytis*, bunch rot and powdery mildew control; in Mexico for use on a range of crops, including maize, dry beans and sugarcane; in Spain; and also in Brazil.  Plant Health Care has a number of agreements regarding the development of Harpin technology in a range of crops, including with Syngenta (a foliar spray for use on glyphosate tolerant crops, later extended to the testing of harpin with fungicides, insecticides and PGRs in Syngenta’s product range); Bayer (brassica oilseed crops); Legacy Seeds (alfalfa); Germain’s Seed Technology (sugarbeet); Arysta (development as a foliar spray in combination with Arysta’s products); and with Adama (foliar spray in combination with Adama products on maize, soybeans and dry beans). The technology has also been licensed to Scotts for development in the lawn and garden care market. Plant Health Care entered into a distribution agreement for harpin with Talc USA and Portuguese firm Edaf Unipessoal and South Africa’s DuxAgri. | | | | | |

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| **Hexaconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 70 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Anvil) | Rallis, Tagros, Bharat Rasayan, Meghmani, Atul, Punjab Chemicals | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 20-50 |
| **Main Crops** | **Main Pests** | | |
| Rice | Sheath blight | | |
| Cereals, F&V | A wide range of diseases | | |
| **Main Mixture Partners :** picoxystrobin | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide now used mainly for the control of rice sheath blight in India and parts of East Asia. Not accepted for Annex 1 re-registration in the EU. | | | | | |

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| **Hexaflumuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | <10 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Consul, Consult) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-50 |
| **Main Crops** | **Main Pests** | | |
| Cotton, F&V | Insects, Aphid, Colorado beetles | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Benzoylurea insect growth regulator of limited commercial significance for crop usage, with minor sales being achieved on cotton, fruit and vegetables. Previously found usage in Dow’s termite control system Sentricon; however this use of the product has been superseded by noviflumuron. Not re-registered in the EU and left that market in 2003. | | | | | |

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| **Hexazinone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 115 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Velpar) | Adama | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence, Post-emergence | **Rate – (g/ha):** 250-13400 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Plantation crops | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diuron | | | | | |
| **Recent History:**  Broad-spectrum triazine herbicide for use on sugarcane, also achieving significant sales in forestry and plantations. Sales have benefitted from the expansion of the sugarcane sector in Brazil driven by the rising demand for ethanol, although generic competition is now present in the country. Has not been supported through re-registration in the EU and left that market in 2003. A mixture with diuron has been introduced as K-4 in the USA. Tessenderlo Kerley acquired the rights outside Brazil to solo formulations of hexazinone, as well as mixture products containing hexazinone and diuron, from DuPont in 2015. The Canadian Pest Management Regulatory Agency has allowed the continued registration of hexazinone after the review that commenced in 2014 due to environmental concerns. | | | | | |

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| **Hexythiazox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 45 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Nissorun) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 5-250 |
| **Main Crops** | **Main Pests** | | |
| F&V, Ornamentals, Maize, Pome fruit | Mites | | |
| **Main Mixture Partners :** fenpropathrin | | | | | |
| **Recent History:**  Highly active specific miticide used predominantly on fruit, citrus and ornamentals, with some sales on vines. Sales in Japan are now well down from peak levels due to resistance development. The product is sold by Gowan as Savey in a number of crop situations in the USA, predominantly fruit and vegetables, and by a number of companies under licence in Europe where it has received approval in the EU. Marketed by Sumitomo Chemical in East Europe in a mixture with fenpropathrin as Danirun. | | | | | |

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| **Hymexazol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other azoles | <30 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Tachigaren) | FarmHannong | | |
| **Application** | **Timing:** | Seed treatment,  Soil applied | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Seedling blight | | |
| F&V, Sugarbeet | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  The first proprietary product introduced by Sankyo. Mainly used as a soil drench and as a seed dressing to prevent damping off caused by the fungal pathogen *Pythium* in sugarbeet and rice. Also used as a drench for tomatoes and other fruit and vegetable crops. Has been re-registered in the EU where it finds some usage on sugarbeet. | | | | | |

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| **Imazalil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other azoles | <30 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Janssen (Fungaflor) | Dow, Adama | | |
| **Application** | **Timing:** | Post-harvest treatment,  Seed treatment, Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V | A wide range of diseases | | |
| Potato | Dry Rot | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Azole fungicide predominantly used in mixtures as a cereal seed treatment for the control of damping off diseases and for control of storage diseases of fruit and potatoes. Particularly effective against benzimidazole-resistant diseases. Also finds usage for powdery mildew control on vegetables and ornamentals. Has achieved re-registration in the EU with approval extended until the end of December 2021. Mitsui & Co’s subsidiary Certis Europe has an exclusive license for the commercialisation of products based on imazalil worldwide, excluding Australia, India and China. Certis subsequently launched an aerosol spray formulation to control *Botrytis* on tomato stems in Belgium and the Netherlands, followed by Fungazil 100 SL in the UK. | | | | | |

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| **Imazamethabenz** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | <10 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nufarm (Assert) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 400-750 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sunflower | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** MCPP | | | | | |
| **Recent History:**  Systemic imidazolinone post-emergence broadleaved and grass weed herbicide particularly for the treatment of wild oats (*Avena* spp.), black grass (*Alopecurus myosuroides*), charlock (*Sinapis arvensis*) and volunteer oilseed rape in winter wheat and winter barley. Passed to BASF on the acquisition of Cyanamid, with Nufarm acquiring the rights to the product outside of Europe in 2005. Not supported through re-registration in the EU and left that market in 2003. Has received approval in Canada. Currently under registration review in the USA. | | | | | |

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| **Imazamox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | 215 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Pulsar, Beyond,Raptor) | None | | |
| **Application** | **Timing:** | Pre- and Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Sunflower, Soybean, Rape, Cereals, F&V, Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** imazethapyr, clopyralid, 2,4-D, bentazone, imazapyr, metazachlor, quinmerac | | | | | |
| **Recent History:**  The most recent imidazolinone introduction, and the only one to achieve re-registration in the EU (until July 2018). This registration has allowed the introduction of Clearfield (imidazolinone-tolerant) crops in the region, now that a re-registered imidazolinone exists in the market. The strength of the product is grass weed control following post-emergence application. Predominantly for use in sunflowers, soybeans, oilseed rape / canola and cereals, being positioned as a Pursuit (imazethapyr) replacement due to less persistence. Recent sales growth has been driven by use on Clearfield crops, primarily sunflower and canola. Also used in a number of mixtures with other imidazolinones, notably with imazethapyr (as Odyssey) on Clearfield canola. Has also been introduced with clopyralid as Tensile for Clearfield canola and with metazachlor and quinmerac as Clearfield Vantiga for use on rape. Other Clearfield crops to be introduced include Clearfield lentils in the USA in 2010 and Clearfield wheat in Australia in 2011, from Australian Grain Technologies. Syngenta has a non-exclusive license to Clearfield Plus technology, whilst BASF supplies the company with imazamox-based herbicides for use with Clearfield and Clearfield Plus sunflowers in Europe. BASF received registration in Canada for Solo ADV for use on Clearfield lentils, canola, sunflowers and soybeans for the 2016 season. The company has also received approval in Germany for Clearfield Clentiga on winter oilseed rape. | | | | | |

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| **Imazapic** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | 80 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Cadre) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Peanuts, Pasture, Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** imazapyr, imazethapyr, imazamox | | | | | |
| **Recent History:**  Pre- and early post-emergence herbicide for the control of broadleaved and grass weeds. Initially introduced for use on peanuts, although sugarcane and rice in Brazil are now the most significant markets. Passed to BASF on the acquisition of Cyanamid. Adama received US approval for a generic version in 2007 for use on peanuts to control broadleaf weeds, grasses and sedges. BASF has also introduced a mixture with imazamox for use on imidazolinone tolerant rice in Brazil, with Embrapa having co-developed a rice line tolerant to this herbicide mixture. Has not achieved EU registration. | | | | | |

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| **Imazapyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | 70 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Euro-Lighning, Aresl) | Adama | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 250-2500 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, Sunflower, Rape, Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** imazapic, imazamox | | | | | |
| **Recent History:**  Total vegetation control herbicide with residual activity used mainly in non-crop situations, particularly in plantation crops, which was passed to BASF on the acquisition of Cyanamid. BASF and Nufarm Americas have a multi-year supply agreement for imazapyr for use in non-crop markets. Adama gained US EPA approval for generic imazapyr for forestry and industrial uses in 2006. Has not been re-registered in the EU. BASF has introduced Kifix (imazapic and imazamox) for use on imidazolinone tolerant rice in Brazil, whilst a similar combination product is used on Clearfield canola in Canada. Imazapyr-tolerant maize has been developed for Kenya. In 2011 Australian Grain Technologies launched a version of imidazolinone tolerant wheat in Australia which can be treated with Intervix, a combination of imazapyr and imazamox. | | | | | |

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| **Imazaquin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | <30 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Cycocel, Scepter) | Adama, Nortox | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence,  Post-emergence | **Rate – (g/ha):** 70-140 |
| **Main Crops** | **Main Pests** | | |
| Turf, Ornamentals, Soybean, Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :**  chlormequat, choline-chloride, fuberidazole, pendimethalin | | | | | |
| **Recent History:**  Broadleaved weed herbicide and at one time a leading product in the soybean sector now superseded by Pursuit (imazethapyr) and Raptor (imazamox) and affected by the uptake of herbicide tolerant varieties. Passed to BASF on the acquisition of Cyanamid. Sales are also achieved from a mixture with pendimethalin (Squadron). Sales on US soybeans have declined significantly, with the main uses now on turf and ornamentals. Now largely replaced by imazethapyr in Latin American markets. In 2016 Amvac obtained a licence to BASF’s Scepter herbicide products in the USA. The Japanese agrochemical company [Agro-Kanesho](https://agrow.agribusinessintelligence.informa.com/AG027998/AgroKanesho-acquires-BASFs-imazaquin-business-in-Japan) acquired BASF’s imazaquin herbicide business in Japan. | | | | | |

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| **Imazethapyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Imidazolinone | 165 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Pursuit) | Adama, Nortox | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence,  Post-emergence | **Rate – (g/ha):** 30-300 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Rice, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** glyphosate, imazamox, clopyralid, sethoxydim, bentazone, metribuzin, imazapic, saflufenacil | | | | | |
| **Recent History:**  At one time the leading soybean herbicide worldwide, although sales were impacted by the uptake of Roundup Ready soybeans. Recent growth has been driven by good acceptance of a co-formulation with glyphosate, Extreme, for use on RR soybeans. Benefits from a broad spectrum of activity and wide window of application. Now subject to generic competition. Not re-registered in the EU and left the market in 2003. FMC has access to the product for the development of combinations for use on soybeans, sunflowers and tobacco. Brazil’s Embrapa has co-developed a rice line tolerant to Only, a mixture with imazapic. In 2012 BASF introduced the product in the USA in a mixture with saflufenacil and dimethenamid-P as OpTill Pro, and in Canada with saflufenacil as OpTill, both for use on soybeans. Odyssey Ultra A (imazamox and imazethapyr) was introduced in Canada in 2015 and gained a label expansion the following year to include usage on faba beans. Adama and US based RiceTec have entered into a collaboration to develop a non-GM herbicide tolerant rice variety, tolerant to Adama’s Preface (imazethapyr) product. | | | | | |

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| **Imazosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Shinobi, Goemon, Take-Off) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** mefenacet, esprocarb, daimuron, pyributicarb | | | | | |
| **Recent History:**  Sulfonylurea herbicide for use in paddy rice, predominantly as the broadleaf weed control element in several ‘one-shot’ products, notably with esprocarb and daimuron as Go Sign; mefenacet and daimuron as Batl; and pyributicarb and daimuron as Award. Originally developed by Takeda, but now marketed by the Sumitomo/Takeda joint venture. The product has also been introduced in South Korea and Taiwan as Take-Off. Initially well received, although sales have suffered with the downturn of the Japanese rice market and competition from new one-shot products. Has achieved registration in the EU, where the product is sold in Italy, Spain and Portugal as Kocis by Sipcam. Also finds sales in the USA for use on turf, as Cerelo from Valent. | | | | | |

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| **Imibenconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Hokko (Manage) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 6-12 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Vine | Apple scab, Peach Scab, Powdery mildew, Brown leaf spot | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Relatively narrow spectrum triazole fungicide used mainly on fruit and vegetables, particularly for the prevention of powdery mildew and scab. Of limited commercial significance. | | | | | |

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| **Imicyafos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphorous | <10 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Nemakick) | None | | |
| **Application** | **Timing:** | Pre-plant Incorporated | **Rate – (g/ha):** 2250-3000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Potato | Root-lesion nematode, Root knot nematode, Cyst nematode | | |
| **Recent History:**  Developed by Agro-Kanesho under the code name AKD-3088. Introduced in Japan in 2009 for use on a range of fruit and vegetable crops. Registered in South Korea in 2012 for use on ornamental melons and water melons. | | | | | |

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| **Imidacloprid** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Neonicotinoid | | 1,020 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Bayer (CropStar, Confidor, Admire) | Excel Crop Care, Rallis, Atul, Meghmani, Nufarm, FMC, Atul, Punjab Chemicals | | | |
| **Application** | **Timing:** | Foliar, Seed treatment | | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | | |
| F&V, Soybean, Rice, Cotton, Cereals, Maize | Corn earworm, aphids, Stink bugs, planthoppers, thrips, weevils, coleoptera, whitefly, others | | | |
| **Main Mixture Partners :**  tebuconazole, bitertanol, pencycuron, thiodicarb, ipconazole, metalaxyl, bifenthrin | | | | | | |
| **Recent History:**  Provides long lasting control of sucking and some biting insects. Finds significant usage in seed treatment, soil and foliar applications, with the main markets being seed treatment in cereals, maize, soybeans, oilseed rape/canola, sugarbeet, sunflower and cotton. Pioneer product for sugarbeet seed treatments, as before its introduction few sugarbeet seeds were treated. Major soil applications are in rice, vegetables, potatoes, turf, ornamentals and tobacco. Use on maize in France was suspended in 2004 due to concerns relating to toxicity to bees. The product has been accepted for Annex 1 approval in the EU, although it has been removed from usage on bee sensitive crops in the region. From 2017 imidacloprid was included in a group of three nenicotinoids that were banned for outdoor use in the EU. Now subject to generic competition, although Bayer continues to introduce new formulations. Nufarm market generic versions of imidacloprid in the USA, as Nuprid for agricultural uses, Mallet for the turf and ornamental sector, and Senator as a seed treatment. Adama launched Sombrero in Canada in 2016 for the control of wireworms on cereals, corn and soybeans and flea beetles in canola. | | | | | | |

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| **Iminoctadine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | <30 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Befran) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** 375-500 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Rice | Rice blast, and a wide range of fruit diseases, *Fusarium*, *Septoria*, *Helminthosporium*, *Tilletia* | | |
| **Main Mixture Partners :** difenoconazole | | | | | |
| **Recent History:**  One of the constituent parts of the fungicide guazatine. Broad-spectrum seed treatment and foliar spray, with the main use being the control of scab (*Venturia* and *Cladosporium*), leaf spot (*Alternaria*) and a range of other diseases in fruit crops; a minor rice blast fungicide and cereal seed treatment. Not re-registered in the EU. Marketed by Bayer in Korea. | | | | | |

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| **Indanofan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Raizin Power, Nichinoh) | None | | |
| **Application** | **Timing:** | Pre- and Post-emergence | **Rate – (g/ha):** 150 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grass weeds | | |
| **Main Mixture Partners :** pyrazosulfuron-methyl | | | | | |
| **Recent History:**  Developed by Mitsubishi Chemical and registered in Japan in 1999. Introduced in Korea where it has sold in a mixture with pyrazosulfuron-methyl as NonDoctor. A 500G formulation has been introduced in Japan which can be applied from the side of the paddy, with equal distribution in the water occurring within 24 hours. Now also incorporated in a number of one-shot rice herbicides in the country. Controls *Echinochloa* up to the three leaf stage, even in cold conditions. Application rates between 250-500 g/ha are required to control annual weeds in upland conditions. Also sold as a pre-emergence herbicide for use on turf as Trebiace. Now part of Nihon Nohyaku following its acquisition of the Mitsubishi business. | | | | | |

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| **Indaziflam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine (alkylazine) | 45 | 2011 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Alion, Specticle, Becano) |  | | |
| **Application** | **Timing:** | Pre-emergence, post-emergence in combinations | **Rate – (g/ha):** 25-100 |
| **Crops** | **Main Pests** | | |
| Turf, Vine, F&V | Broad spectrum of broadleaf weeds and grasses | | |
| **Main Mixture Partners:** diquat dibromide, glyphosate, isoxaflutole | | | | | |
| **Recent History:**  Inhibits cellulose biosynthesis and acts on meristematic cell growth. Can be applied either pre-emergence on its own, or post-emergence in conjunction with other post-emergent herbicides. First approval achieved in the USA in 2010. Introduced in the country as Specticle for turf and as Alion for fruit & vegetables and tree nuts. Alion has also been introduced in Brazil and Chile. In 2014 Bayer launched Specticle Total (indaziflam, diquat dibromide and glyphosate) for non-crop applications in the USA. Merlin Total (isoxaflutole and indaziflam) for use on sugarcane was launched in El Salvador in 2015. | | | | | |

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| **Indoxacarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 210 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Avatar, Avaunt, Steward) | Atul | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 12.5-70 |
| **Main Crops** | **Main Pests** | | |
| F&V, Soybean, Pome fruit, Vine | A wide range of insects | | |
| Cotton | Bollworm complex, other Lepidoptera | | |  | |
| **Main Mixture Partners :** teflubenzuron | | | | | |
| **Recent History:**  Mode of action for Lepidoptera control involves the blocking of sodium channels, which was unique at the time of launch. Low application rates and a novel mode of action have led to considerable commercial success. Introduced in 2000 in the USA as Avaunt for use on fruit and vegetable crops for the control of major worm pests (ovicide and larvicide), but also with a broad spectrum of activity against insect pests, particularly of pome fruit. The product is marketed as Steward for bollworm control on cotton, providing a good fit for use on *B.t.* cotton. Has achieved full Annex 1 registration in the EU and has been introduced in several European markets for use on vine and fruit. EU approval is valid until the end of October 2017. Introduced in India on cotton to good reception, with usage in the country now expanded to several other crops, notably fruit and vegetables. Syngenta acquired DuPont’s Professional Products business in 2012, including the Advion fire ant bait product for use on turf. DuPont and Arysta LifeScience launched the product as Ammate in Myanmar in 2013. Introduced as Avatar for the control of earworms on soybean and cotton in Brazil in 2014. FMC has agreed to acquire DuPont’s divested cereal herbicides including indoxacarb, as required by US and EU regulators because of the Dow-DuPont merger. | | | | | |

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| **Iodosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS-Sulfonylurea | 135 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Atlantis, Hussar, MaisTer) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 10 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Broadleaf and some Grass weeds | | |
| **Main Mixture Partners :**  foramsulfuron, mesosulfuron-methyl, amidosulfuron, fenoxaprop-P-ethyl, terbuthylazine, 2,4-D ethyl ester, mefenpyr, mefenpyr-diethyl | | | | | |
| **Recent History:**  Developed by Aventis as AEF 115008, now part of Bayer following its acquisition of the company. Has received approval in the EU, where it has gained a leading position in the cereal herbicide market in combination with mesosulfuron as Atlantis. EU approval has been extended until 2032. Iodosulfuron is a component of many mixture products, with the most recently introduced being with fenoxaprop and the safener mefenpyr as Hussar; with amidosulfuron and mefenpyr as Chekker; with mesosulfuron and mefenpyr as Mesomaxx; with foramsulfuron for use on maize as Fortuna and Option; and with amidosulfuron as Sekator for use on cereals, with Sumitomo Chemical’s UK subsidiary Interfarm holding the marketing rights to this product. Has also been introduced in the USA as Autumn for burndown and residual weed control in maize. | | | | | |

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| **Ioxynil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other - Hydroxybenzonitrile | <30 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Actinol, Actril) | Nufarm, Adama, Dow | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100-625 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V, Plantation crops | Broadleaved weeds | | |
| **Main Mixture Partners :** bromoxynil, MCPP, diflufenican, beflubutamid, mecoprop | | | | | |
| **Recent History:**  Hydroxybenzonitrile herbicide which is an iodinated analogue of bromoxynil for broadleaf weed control, primarily on winter germinating weeds. Manufactured through a joint venture between Bayer and Nufarm. Has been refused re-registration in the EU. Arysta’s Czech subsidiary distribute the product in a mixture with beflubutamid and mecoprop as Trioflex in the Czech Republic and Slovakia. | | | | | |

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| **Ipconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 35 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kureha (Techlead) | Arysta LifeScience | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice, Cereals, Ornamentals | Seedling blight, *Curvularia* spp. | | |
| **Main Mixture Partners :** metalaxyl, imidacloprid, cypermethrin, clothianidin, ethaboxam | | | | | |
| **Recent History:**  Systemic triazole seed treatment for the control of seedling blight in rice, also for control of bakanae disease, *Helminthosporium* and blast. Chemtura (now Arysta LifeScience) has global development and commercialisation rights for the product and have launched a number of seed treatment products, including Rancona for use on soybeans and Rancona Apex for use on cereals. Other products in the Rancona range include Rancona Summit, with metalaxyl, for use on soybeans and dry beans; Rancona Pinnacle, a mixture with metalaxyl; Rancona Crest, with metalaxyl and imidacloprid; and Rancona C, with cypermethrin for use on cereals. Has gained EU approval and inclusion on Annex 1. In 2015 Valent introduced the Intego Suite Soybeans seed treatment product (ethaboxam, ipconazole, metalaxyl and clothianidin) in the USA. Arysta LifeScience launched Rancona (ipconazole, carboxin) fungicidal seed treatment for use on US soybean in 2017. | | | | | |

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| **Ipfencarbazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other (Triazolinone) | <30 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Hokko (Winner) |  | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 250 |
| **Crops** | **Main Pests** | | |
| Rice | Broadleaf and Grass weeds | | |
| **Main Mixture Partners:** imazosulfuron, bromobutide, bensulfuron-methyl | | | | | |
| **Recent History:**  Developed by Hokko as HOK-201. Launched by Sumitomo Chemical in Goemon G (with imazosulfuron and bromobutide) in Japan in 2014 for use on rice. Is due to be introduced by Hokko as Winner (ipfencarbazone, bromobutide and bensulfuron-methyl). | | | | | |

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| **Iprobenfos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Kitazin-P) | Pesticides India | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 450-850 |
| **Main Crops** | **Main Pests** | | |
| Rice, F&V | Rice blast, Sheath blight, Stem rot | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Systemic fungicide applied in granular formulation to flooded paddy fields. Also has some anti-lodging activity and is claimed to be synergistic with some insecticides. | | | | | |

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| **Iprodione** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Dicarboxamide | 115 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF, FMC  (Rovral) | Bayer, Chimac-Agriphar, FarmHannong, DevGen | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 560-2240 |
| **Main Crops** | **Main Pests** | | |
| Vine | *Botrytis* | | |
| F&V, Peanuts, Pome fruit, Rape | A wide range of diseases | | |
| **Main Mixture Partners :** thiram, carbendazim | | | | | |
| **Recent History:**  Broad spectrum fungicide with applications on a wide range of crops. The major use for the product is on soft fruit and vines for the prevention of *Botrytis* and *Monilia*, with similar activity against a various diseases on vegetables. Also finds usage as a seed treatment on rape and cereals. Usage has been expanded through the introduction of mixture formulations. Bayer divested global seed treatment and foliar uses in Europe to BASF following the acquisition of Aventis. FMC acquired Bayer’s non-European Rovral business in 2011. EU re-registration is dated for 2018, but in 2017 EU member states supported a proposal not to renew the approval, so the exact EU approval period remains uncertain. DevGen have introduced the product as a nematicide for use on peanuts in the USA as Enclosure. Cheminova (now FMC) distribute DevGen’s nematicide as Devguard in Greece, Italy, Spain and Portugal for use on greenhouse vegetables. In 2012 Adama received approval in Canada for use on canola as Overall 240 SC. In 2013 SipcamAdvan launched Eclipse in the USA for use on turf, incorporating the company’s ETQ formulation technology. Gained registration approval for use in China during 2015. | | | | | |

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| **Iprovalicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Melody, Invento) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 120-300 |
| **Main Crops** | **Main Pests** | | |
| Vine, F&V, Tobacco | Oomycete diseases including Downy mildew, Late Blight and others | | |
| **Main Mixture Partners :** propineb, tolylfluanid, folpet, mancozeb | | | | | |
| **Recent History:**  Systemic fungicide for the control of oomycete diseases. Amino acid carbamate fungicide also with applications for the control of *Phytophthora* soil borne diseases in tobacco, citrus and other crops. A number of mixture formulations have been commercialised with tolylfluanid, folpet, mancozeb and propineb. Has been introduced in most European, Latin American and Asian markets. | | | | | |

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| **Isofenphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Chinese Companies (Oftanol) | None | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** 1000-5000 |
| **Main Crops** | **Main Pests** | | |
| Maize, Cereals | A wide range of insects and nematodes | | |
| **Main Mixture Partners :** triadimefon | | | | | |
| **Recent History:**  Broad-spectrum organophosphate insecticide for the control of soil insects, leaf eating and sucking pests. A niche market product with limited sales. All US registrations have been cancelled, and the product has not been re-registered in the EU. In 2011 authorities in China stopped accepting new applications for field testing, registration or manufacturing permits with these measures to lead to an eventual ban of the product in the country. | | | | | |

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| **Isofetamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | <10 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Rape | Grey mould, Powdery mildew | | |
| **Recent History:**  Developed by Ishihara as IKF-5411. Introduced by Summit Agro in the USA for use on strawberries to control grey mould. Isofetamid has gained approval in Canada and proposed approval in EU for Vine, Canola, lettuce and berries. | | | | | |

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| **Isoprocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <30 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Mipcin) | Chinese companies | | |
| **Application** | **Timing:** | Foliar, soil applied | **Rate – (g/ha):** 250-1500 |
| **Main Crops** | **Main Pests** | | |
| Rice | Brown plant hopper, Green leaf hopper, Other leaf hoppers | | |
| **Main Mixture Partners :** buprofezin | | | | | |
| **Recent History:**  Contact carbamate molluscicide/insecticide active against both soil borne and foliar pests, mainly used in rice. Previously also sold by Bayer, although the company have now withdrawn from the product. Of minor commercial importance. Now marketed by Nihon Nohyaku in Japan following their purchase of the Mitsubishi Chemicals agrochemical business. | | | | | |

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| **Isoprothiolane** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 45 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Fuji-One) | FarmHannong, Atul | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 360-6000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Stem rot, Rice blast | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Mature carbamate fungicide for rice blast and stem rot control, also with activity against brown planthopper. The product has not been re-registered in the EU and left that market in 2003. The main markets are in Asia and Latin America. In 2010 Nihon Nohyaku launched a new formulation of the product as Fuji-One Fertera Ryuzai. | | | | | |

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| **Isoproturon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | 55 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Quartz, Javelo) | Adama, Gharda, IPiCi, UPL, Bharat Rasayan | | |
| **Application** | **Timing:** | Pre-emergence,  Post-emergence | **Rate – (g/ha):** 1000-2500 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diflufenican, amidosulfuron, pendimethalin, beflubutamid | | | | | |
| **Recent History:**  Commodity herbicide for broad leaf weed control in cereals, however sales have declined due to generic competition, resistance development and the success of competitive products. The product has also become subject to regulatory scrutiny due to groundwater concerns, with use in the UK phased out in 2009 and application restrictions in place in France. Syngenta replaced the product in their portfolio with clodinafop. In 2011 Arysta’s Czech subsidiary entered into an agreement with Cheminova (now FMC) to distribute Cheminova’s products Herbaflex and Aland, both of which are mixtures with beflubutamid, in the Czech and Slovakian markets. Has not achieved EU re-registration. | | | | | |

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| **Isopyrazam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 40 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Seguris, Symetra) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cereals | Protectant activity against a wide range of diseases including Septoria | | |
| **Main Mixture Partners:** cyprodinil**,** epoxiconazole, azoxystrobin | | | | | |
| **Recent History:**  Active by inhibition of succinate dehydrogenase, used mainly in mixture formulations. Received its first approval in 2010 in the UK as Bontima in combination with cyprodinil for use on barley. Further introductions include as Seguris, a combination with epoxiconazole for use on wheat, barley, triticale and rye, in the UK and Germany. Has received EU registration with approval extended until the end of March 2023. Also introduced in Argentina as Reflect Extra in 2014. In 2015 Syngenta gained approval in China for the manufacture of the product in the country. In 2017 isopyrazam was launched in Italy for use on vegetables as the product Reflect. | | | | | |

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| **Isotianil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer / Sumitomo Chemical (Routine) |  | | |
| **Application** | **Timing:** | Nursery box and Seed treatment | **Rate – (g/ha):** 100-300 |
| **Crops** | **Main Pests** | | |
| Rice | Blast | | |
| **Main Mixture Partners:** imidacloprid, spinosad, thifluzamide, cyantraniliprole | | | | | |
| **Recent History:**  Co-developed by Bayer and Sumitomo Chemical. Active via induction of systemic resistance in rice plants. Can be used as a seed treatment as well as in rice nursery boxes, reportedly at low application rates. Launched in Korea and Japan in 2010. In 2011 Nissan Chemical introduced the product in a mixture with imidacloprid, spinosad and thifluzamide as Shario in Japan for rice nursery box application. Bayer’s Routine Duo Box GR (cyantraniliprole and isotianil) achieved approval for use in Japan in 2014. Commercial introduction in other major rice growing countries in Asia is expected to follow. | | | | | |

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| **Isoxaben** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <30 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Gallery, Cent, Flexidor) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 125-150 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V, Vine, Pone fruit | Broadleaved weeds | | |
| **Main Mixture Partners :** florasulam | | | | | |
| **Recent History:**  Pre-emergence broadleaved weed herbicide, with the main crop uses being in European cereals, primarily in mixtures. Has received re-registration in the EU. Adama’s US-based business Quali-Pro has introduced the product in the USA for turf and ornamentals. Dow launched the product in the USA as Trellis for use on vines and tree nuts in 2011, and as Gallery SC for a range of crops and ornamentals. | | | | | |

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| **Isoxaflutole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | 220 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Corvus, Provence, Balance) | None | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 125-175 |
| **Main Crops** | **Main Pests** | | |
| Maize, Sugarcane, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** aclonifen, atrazine, flufenacet, thiencarbazone | | | | | |
| **Recent History:**  Quickly gained acceptance in the US maize herbicide market despite difficult market conditions and the success of herbicide tolerant varieties. Mode of action promotes usage in resistance avoidance strategies and mixtures with other products, notably with flufenacet. Originally developed by Aventis and now part of the Bayer portfolio, whilst Certis hold the marketing rights to the product in Benelux countries. Has received registration in the EU with approval extended until the end of July 2017. DuPont has access to the product for use in maize herbicides in the USA. Has benefitted from introduction in a mixture with thiencarbazone for use on maize as Corvus in the USA and as Adengo in Argentina, Italy and Portugal. Also introduced in Italy in 2011 with the safener cyprosulfamide as Merlin Flexx, also for use on maize. Also finds significant usage on sugarcane in Brazil on, where it is one of the leading herbicides used on the crop. Bayer has also launched Merlin Total (isoxaflutole and indaziflam) for use on sugarcane in Guatemala and El Salvador. Bayer and MS Technologies have received cultivation approval from the USDA for their dual herbicide tolerance soybean trait Balance GT, which confers tolerance to isoxaflutole and glyphosate. Similar approval has also been received in Canada, with import approvals granted in Australia and New Zealand. Syngenta and Bayer also have an agreement for the co-development of HPPD-tolerant soybeans. | | | | | |

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| **Isoxathion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL / Hodogaya (Cypercal, Karphos) | None | | |
| **Application** | **Timing:** | Foliar, Soil applied | **Rate – (g/ha):** 150-2700 |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops | Leaf beetle, Stem borer, Water weevil, Mites, range of Insects | | |
| **Main Mixture Partners :** cypermethrin | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus insecticide with action against a range of soil and foliar pests and mites. Main usage is on fruit and vegetable crops. Not re-registered in the EU. Acquired by the UPL / Hodogaya joint venture from Sankyo in 2008. | | | | | |

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| **Jun Si Qi** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Shenyang Research Institute (Jun Si Qi) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-400 |
| **Main Crops** | **Main Pests** | | |
| F&V | *Botrytis*, White rot, Grey mould | | |
| **Recent History:**  Developed under the code name SYP-Z048, the product does not currently have an ISO approved name. Introduced in China in 2006 for use against grey mould in tomatoes. | | | | | |

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| **Kasugamycin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 65 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Hokko (Kasumin) | DongBang Agro, Arysta LifeScience | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 30-80 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| F&V, Potato | A wide range of diseases | | |
| **Main Mixture Partners :** phthalide, tricyclazole | | | | | |
| **Recent History:**  Systemic fungicide for the control of rice blast, also used against bacterial leaf blight and bacterial leaf stripe (*Xanthomonas* spp.) and a range of diseases of fruit and vegetables, especially bacterial diseases resulting from *Pseudomonas* infection. Sold in a mixture with phthalide in Korea. Arysta has introduced Kasumin in Pakistan for use on rice; Kasai-S, an SC formulation with tricyclazole, in Vietnam, for use on rice; and as Kasumin 2S in Canada for a wide range of fruit and vegetables. | | | | | |

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| **Kresoxim-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 125 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Allegro, Juwel) | Adama, Rallis | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-400 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Asia rust | | |
| F&V | A wide range of diseases | | |
| Cereals | Brown rust, *Septoria* leaf spot, Net blotch, Powdery mildew | | |
| Vine | Excoriosis, Powdery mildew | | |
| **Main Mixture Partners :** epoxiconazole, fenpropimorph, pyraclostrobin, dithianon, carbendazim, tebuconazole | | | | | |
| **Recent History:**  Broad-spectrum strobilurin fungicide initially launched for use on cereals, rapidly gaining market acceptance following its introduction in 1996. Has subsequently lost market share to second and third generation products, although some usage has been sustained by introduction on other crops, notably vines and pome fruit. Crop coverage is not as great as for its major competitors. In the USA, Scotts have an agreement with BASF to market the product as Cygnus for turf and ornamental usage. Introduced in Canada as Sovran in 2001. Has received EU re-registration with approval extended until the end of December 2021. Sipcam introduced a kresoxim, epoxiconazole and fenpropimorph mixture as Ogam in France in 2003. Cheminova, now part of FMC, received exclusive US distribution rights for the product as Sovran from BASF in 2011. FMC introduced the product in a mixture with carbendazim and tebuconazole as Locker in Brazil in 2012. | | | | | |

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| **KSF-1002** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kyung-Nong |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V | Blight and other diseases | | |
| **Recent History:**  Developed by the KRICT in Korea and licensed to Kyung-Nong for development. Yet to make any commercial impact. | | | | | |

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| **Lactofen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | 40 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Cobra, Phoenix) | Bayer, Adama | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 125 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Diphenyl ether herbicide introduced by Chevron but later divested to Hoechst and Sumitomo Chemical. The product has rapid action against broadleaved weeds in soybean. Initially suffered from phytotoxicity problems, but subsequently repositioned resulting in sales growth in the US soybean sector. However, sales have since been impacted by the success of herbicide tolerant soybeans. Valent has introduced Phoenix, an adjuvant containing formulation for US soybeans. Phoenix and Cobra were added to Monsanto’s Roundup Ready Plus weed control platform in 2011. | | | | | |

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| **Lambda-cyhalothrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 595 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Karate) | Tagros, Adama, Rallis, Heranba, Bharat Rasayan, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-40 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Cutworm, Corn earworm, Fall armyworm, Soybean looper | | |
| Cereals | Corn rootworm, Cutworm, Armyworm, many others | | |
| Maize | European corn borer, Corn rootworm, Cutworm, many others | | |
| F&V, Cotton, Rape, Rice, Sugarcane | A wide range of insects | | |
| **Main Mixture Partners :** pirimicarb, thiamethoxam, chlorantraniliprole, tebuconazole, sulfoxaflor | | | | | |
| **Recent History:**  The leading pyrethroid insecticide worldwide, with a broad range of uses on a wide variety of crops, with extensive usage also taking place in animal and public health situations. The product has been repositioned in the USA and other major markets with the incorporation of Zeon micro-encapsulation technology allowing an initial fast release of the product, followed by a sustained release to increase the persistence of the treatment. Now subject to generic competition, notably from Adama. Dow and Cheminova (now part of FMC) introduced gamma-cyhalothrin, a more highly resolved form of the molecule, in 2003. Syngenta has introduced a number of mixtures, including with chlorantraniliprole as Voliam Express and Besiege; and with thiamethoxam as Endigo. Innvictus Crop Care introduced Crossover, a mixture with tebuconazole for use on a variety of crops, in 2014, whilst in the same year Dow gained US registration for Seeker, a mixture with sulfoxaflor. In 2016 Syngenta’s Ballista LFC was approved for the control of a range of corn pests in the USA. Has gained EU re-registration. In 2017, Brazil approved Nufarm’s Kaiso Sorbie (lambda-cyhalothrin) for use on cotton. | | | | | |

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| **Lenacil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <30 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Venzar) | Schirm, Punjab Chemicals | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 400-2000 |
| **Main Crops** | **Main Pests** | | |
| Sugarbeet, Non-crop, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** ethofumesate, metamitron | | | | | |
| **Recent History:**  Residual broadleaved weed herbicide for sugarbeet, mostly used in Europe. Further sales are achieved in non-crop situations. Re-registration in the EU has been achieved with approval until the end of December 2018. FMC has agreed to acquire part of DuPont cereal herbicides portfolio including lenacil, as required by EU and US regulators over the Dow-DuPont merger. | | | | | |

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| **Lepimectin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Avermectin | <10 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Aniki) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 10 - 30 |
| **Crops** | **Main Pests** | | |
| F&V, Vine, Tea | A wide ranges of insects and mites | | |
| **Recent History:**  The product is a mixture of two components: the main component is the 6-ethyl analogue, with the minor component being the 6-methyl version. Formulations developed as SI-0009EC (1% EC) and SI-0205FL (1% FL). Received registration in Japan in 2010 for use on a range of fruit and vegetable crops. Has not been approved for use in the EU. | | | | | |

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| **Lindane**  **(Gamma-HCH)** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organochlorine | <10 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Inquinosa | Hindustan Insecticides | | |
| **Application** | **Timing:** | Foliar, Seeds treatment, Soil applied | **Rate – (g/ha):** 50-2250 |
| **Main Crops** | **Main Pests** | | |
| Maize, Cereals, Cotton | A wide range of insects and Nematodes. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity organochlorine insecticide, now facing widespread regulatory restrictions, with the product banned or restricted in many markets. Main existing use in developed markets is as a seed treatment. Withdrawn from the EU market in 2001, whilst the US cancelled the registration of all crop uses in 2006. Also banned in Canada in 2005 and withdrawn from Brazil in 2006. Mexico has eliminated all agricultural, veterinary and pharmaceutical uses, with Australia cancelling all registrations for the product in 2010, India also phasing out the product in the same year. | | | | | |

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| **Linuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | 40 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Afalon) | Tessenderlo Kerley, IpiCi | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 560-3400 |
| **Main Crops** | **Main Pests** | | |
| Potato, F&V, Soybean, Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** monolinuron, diuron, terbuthylazine, pendimethalin, aclonifen, thiobencarb, fluazifop-P | | | | | |
| **Recent History:**  Broad-spectrum urea herbicide offering pre-emergence control of a wide range of weeds. This activity has taken the product into many crop sectors with the compound now used predominantly in mixtures. Bayer divested its worldwide rights to the product to Adama following the acquisition of Aventis, whilst DuPont divested its linuron assets to Tessenderlo Kerley in 2009. Re-registration in the EU has been unsuccessful in 2017. Ishihara gained Japanese registration for the product in a mixture with fluazifop-P as One Cross in 2012. | | | | | |

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| **Lufenuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 150 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Match, Curyom) | Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-30 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Lepidoptera, Thrips | | |
| Cotton | Bollworm complex, Other Lepidoptera, Whitefly, Thrips, Aphids | | |
| F&V | A wide range of insects and mites | | |
| Maize | Corn Rootworm, European Corn Borer, Cutworm, Armyworm, Cornstalk Borer | | |  | |
| **Main Mixture Partners :** profenofos, fenoxycarb | | | | | |
| **Recent History:**  Benzoylurea insect growth regulator, a leading product for Spodoptera control on cotton in Latin America. The product fits well in the Syngenta insecticide strategy with emamectin as it provides late season insect control on vegetables and complements resistance avoidance programmes. Syngenta has also introduced Curyom, a mixture with profenofos, in Argentina for use on soybeans. Has achieved re-registration in the EU with approval until the end of December 2019. Also achieves significant sales in animal health, where it is sold as an oral ectoparasiticide for flea control on cats and dogs under the trade name Program. Other uses include public health, as the active ingredient in the termite bait Zyrox. Currently under review for use in the USA. | | | | | |

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| **Magnesium phosphide** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | | <30 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure**  MgP | |
| UPL |  | | | |
| **Application** | **Timing:** |  | | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | | |
| Non-crop | Vermin Control | | | |
| **Main Mixture Partners :** | | | | | | |
| **Recent History:**  Reacts with water to release phosphine, mainly used for insect control in stored commodities. Restrictions for the use of the product for rodent burrow fumigations were tightened by the US EPA in 2010. Has received EU Annex 1 approval with approval until the end of August 2022. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits and have withdrawn registrations for the product, with these measures to lead to an eventual ban in the country. Gained approval in Canada during 2015, with certain use restrictions. | | | | | | |

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| **Malathion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 80 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Malathion 1000, Fyfanon) | Sumitomo, Ficom, Hindustan Insecticides, Rallis, Gowan | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 270-5600 |
| **Crops** | **Main Pests** | | |
| Cotton | Boll weevil | | |
| F&V, Rice | A wide range of insects and mites | | |
| **Main Mixture Partners :**  mineral oil, gamma-cyhalothrin | | | | | |
| **Recent History:**  Broad-spectrum organophosphorous insecticide with acaricidal activity with applications in crop, livestock and public health situations. Usage on lawns has been revoked in the USA, however other uses are deemed acceptable at reduced application rates. The product was re-registered in the EU in 2010, having previously been removed from the market. Gained US EPA registration in 2010 as Fyfanon Plus ULV, a mixture with gamma-cyhalothrin, for use on cotton. Being phased out in New Zealand, although Canadian approval has been achieved, subject to certain risk mitigation measures. | | | | | |

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| **Maleic hydrazide** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | | <30 | 1948 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Arysta LifeScience (Royal) | Punjab Chemicals | | | |
| **Application** | **Timing:** | Foliar,  Post-harvest | | **Rate – (g/ha):** 3000 |
| **Crops** | **Main Pests** | | | |
| Plantation crops, Non-crop, F&V, Potato | n.a. | | | |
| **Main Mixture Partners :** dicamba, MCPA | | | | | | |
| **Recent History:**  Plant growth regulator which inhibits cell division in plants, and finds use for the removal of suckers from tobacco, inhibition of sprouting and suppression of growth in other crops. Also finds usage in non-crop sectors for suppression of grass growth. Achieved full Annex 1 re-registration in the EU, extended until 2032. The US EPA reassessed maleic hydrazide tolerances in 2005, and concluded that no risk mitigation was required. Manufactured by Chemtura (now Arysta LifeScience following the Platform Specialty Products acquisition) as Rovral. | | | | | | |

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| **Mancozeb** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Dithiocarbamate | | 665 | 1943 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:**  BASF, DuPont, UPL, Indofil, Chinese companies | | | | **Structure** | |
| Dow AgroSciences (Dithane) |
| **Application** | **Timing:** | Foliar,  Seed treatment | | **Rate – (g/ha):** 1250-5000 |
| **Crops** | **Main Pests** | | | |
| Potato | Black scurf, Early blight, Potato blight | | | |
| Vine | Downy mildew, Black rot, Excoriosis | | | |
| Rice | Stem Rot | | | |
| F&V, Plantation crops, Pome fruit, Cereals | A wide range of diseases | | | |
| **Main Mixture Partners :**  dimethomorph, metalaxyl, thiophanate-methyl, propamocarb, cymoxanil, benalaxyl, fosetyl-al, zoxamide, copper-oxychloride, fenamidone, oxadixyl, chlorothalonil, picoxystrobin, tebuconazole | | | | | | |
| **Recent History:**  Commodity broad-spectrum EBDC contact fungicide with a wide range of crop applications, utilised in many mixtures. The product benefits from usage in combination with single site systemic products in resistance avoidance strategies, particularly on fruit & vegetable crops. Has received full Annex 1 re-registration in the EU with approval until the end of January 2018. UPL acquired DuPont’s global non-mixture mancozeb business and related assets in 2010, whilst Indofil acquired Dow’s European Dithane business in 2012, including all trademarks and rights to the patented NT formulation technology. The Canadian PMRA has proposed to phase out seed treatment usage in some cereal crops, as well as apples, pears, grapevine and tomatoes. | | | | | | |

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| **Mandestrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <30 | 2016 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Pinpoint) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 259-473 |
| **Crops** | **Main Pests** | | |
| Maize, Rape, F&V, Turf, Vine | Grey mould (*Botrytis cinerea*), dollar spot (*Sclerotinia homoeocarpa*) | | |
| **Recent History:**  Gained US EPA approval as Intuity and Pinpoint in 2016 for foliar use on particular small-fruit climbing vines and low-growing berries (except cranberries), and turf, respectively. Also gained approvals in Canada as Intuity, Pinpoint and S-2200 4 SC for foliar use to on oilseeds, grapevines, low-growing berries (including strawberries) and turf. The seed treatment S-2200 3.2 FS, was also approved in 2016 in Canada for use on maize, legume vegetables and oilseeds. Also in 2016, the a.i. was approved as Intuity in Australia for the control of brown rot (*Monolinia fructicola*) on stone fruit. In 2017, the a.i. was approved as Intuity in New Zealand for the control of white rot and downy mildew in onions, and white mould (*Sclerotinia sclerotiorum*) in beans. Gained EU approval in 2015. | | | | | |

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| **Mandipropamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other (mandelamide) | 120 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Revus) |  | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 100 - 150 |
| **Crops** | **Main Pests** | | |
| Potato, F&V, Vine, Tobacco | Oomycete diseases (potato and tomato late blight etc.) | | |
| **Main Mixture Partners :** mancozeb, folpet, chlorothalonil, difenoconazole, zoxamide, oxathiapiprolin | | | | | |
| **Recent History:**  Specific oomycete fungicide, mainly used as a mixture partner with mancozeb, folpet or chlorothalonil depending on market requirements. Exhibits preventative control of oomycete diseases and also some curative activity during the disease incubation period. Highly active against spore germination and also inhibits mycelial growth and sporulation. First registrations were received in Austria and South Korea in 2007. This was followed by a number of other country markets, including the USA, as Revus for use on vegetables and grapes, and with difenoconazole as Revus Top for use on tomatoes and potatoes. Has also received registration for use on ornamentals in Brazil, Colombia and the USA. Has received registration in the EU with approval until the end of July 2023. In 2014 Syngenta launched the combination potato fungicide Amphore Plus, which also contains difenoconazole, in the UK. Syngenta launched Prondis Ultra, a mixture with oxathiapiprolin, in Canada in 2016. In 2017 Syngenta launched Revus Top (mandipropamid, difenoconazole) in Argentina and Chile for use on Potatoes. Canada also registered Revus as a seed treatement for potatoes. | | | | | |

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| **Maneb** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Dithiocarbamate | | <30 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| UPL (Vondac, Manzate D) | BASF, Dow | | | |
| **Application** | **Timing:** | Foliar, Seed treatment | | **Rate – (g/ha):** 1125-4500 |
| **Crops** | **Main Pests** | | | |
| Potato | Potato blight | | | |
| F&V, Peanuts | A wide range of diseases | | | |
| **Main Mixture Partners :** carboxin, cymoxanil, fentin-acetate, flutriafol | | | | | | |
| **Recent History:**  Broad-spectrum commodity fungicide with a wide range of applications, particularly in fruit & vegetable crops. Some minor uses have been lost due to the cost of re-registration, and has not been re-registered in the EU. No US registrations exist following the EPA’s cancellation of these at the request of the registration holders UPL and Drexel. | | | | | | |

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| **MCPA** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Phenoxy | | 140 | 1945 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Nufarm (MCPA) | Dow, UPL, Adama, Atanor, Shandong Qiaochang Chemical | | | |
| **Application** | **Timing:** | Post-emergence | | **Rate – (g/ha):** 120-1600 |
| **Crops** | **Main Pests** | | | |
| Cereals, F&V, Rice | Broadleaved weeds | | | |
| **Main Mixture Partners :**  bromoxynil, tralkoxydim, florasulam, clopyralid, fluroxypyr, tribenuron-methyl, dichlorprop-P, MCPP-P, dicamba, glyphosate, bentazone, thiencarbazone-methyl, thifensulfuron, pyraflufen-ethyl | | | | | | |
| **Recent History:**  Mature phenoxy herbicide for low-cost post-emergence control of broadleaved weeds particularly in cereals, but also in a range of fruit and non-crop situations. Some sales in developed markets have been replaced by more advanced solutions. BASF divested their interests in the product, and other phenoxy herbicides, to Nufarm in 2004. Has received re-registration in the EU with approval until the end of October 2018. Widely used in combination with other products, recently from DuPont with Predicade (thiencarbazone, tribenuron, thifensulfuron, fluroxypyr and MCPA) for broad spectrum weed control on Canadian spring and durum wheat; Outshine (florasulam and fluroxypyr in a co-pack with MCPA ester); and Rush M (a co-pack containing fluroxypyr and MCPA ester) from Adama, also for Canadian cereals. In 2016 Nufarm launched New Goldwing, a mixture with pyraflufen-ethyl, in Canada. | | | | | | |

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| **MCPB** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Phenoxy | | <30 | 1955 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Dow AgroSciences | Nufarm | | | |
| **Application** | **Timing:** | Post-emergence | | **Rate – (g/ha):** 675-1035 |
| **Crops** | **Main Pests** | | | |
| F&V, Rice | Broadleaved weeds | | | |
| **Main Mixture Partners:** simetryn, molinate | | | | | | |
| **Recent History:**  Minor phenoxy herbicide mainly used for post-emergence broadleaved weed control in cereals, peas and beans. MCPB ethyl is also used in mixtures on rice. Has received re-registration in the EU with approval until the end of October 2018. | | | | | | |

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| **Mecoprop** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Phenoxy | | 45 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Nufarm (Duplosan, U46, KV Fluid) | UPL, PBI-Gordon | | | |
| **Application** | **Timing:** | Post-emergence | | **Rate – (g/ha):** 1800-3900 |
| **Crops** | **Main Pests** | | | |
| Cereals | Broadleaved weeds | | | |
| **Main Mixture Partners :** MCPA, Dicamba, bromacil | | | | | | |
| **Recent History:**  Phenoxy herbicide for broadleaved weed control, now replaced in many markets by the resolved form mecoprop-P introduced as Duplosan KV by BASF and as Optica by A H Marks (now Nufarm). BASF divested their interests in the product and other phenoxy herbicides to Nufarm in 2004. Re-registration in the EU ended in 2017, with the resolved form mecoprop-p receiving approval until the end of January 2018. All racemic mixtures were phased out in Canada in 2009 and replaced with the resolved mecoprop-P, with mecoprop-P also deemed eligible for re-registration by the US EPA, providing certain risk mitigation measures are followed. | | | | | | |

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| **Mefenacet** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | | <30 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Bayer (Hinochloa, Rancho) | None | | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | | **Rate – (g/ha):** 600-1600 |
| **Crops** | **Main Pests** | | | |
| Rice | Grasses | | | |
| **Main Mixture Partners :** bensulfuron-methyl, fenoxaprop-P-ethyl, pyrazosulfuron-ethyl, imazosulfuron, tefuryltrione | | | | | | |
| **Recent History:**  Rice herbicide used for grass weed control, especially *Echinochloa crus-galli* (barnyard grass), mainly used in mixture products for ‘one-shot’ weed control, the most significant being Zark G and Power Wolf. Not supported through re-registration in the EU and left that market in 2003. The product is now complemented by fentrazamide in the Bayer portfolio. | | | | | | |

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| **Mepanipyrim** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Anilinopyrimidine | | <30 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Kumiai (Frupica) | None | | | |
| **Application** | **Timing:** | Foliar | | **Rate – (g/ha):** 200-750 |
| **Crops** | **Main Pests** | | | |
| Vine | *Botrytis* | | | |
| F&V | A wide range of diseases | | | |
| **Main Mixture Partners :** | | | | | | |
| **Recent History:**  Anilinopyrimidine fungicide for the control of grey mould (*Botrytis cinerea*), powdery mildew (*Sphaerotheca* spp.), and scab (*Venturia* spp.) with contact action against cell wall degrading enzymes. Sold by the Mitsui & Co subsidiary Certis in a number of European markets, including Belgium, France and Spain, as Japica. EU approval has been extended until May 2018. | | | | | | |

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| **Mepiquat** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | | 95 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| BASF (Pentia,Pix) | Gharda, Nufarm | | | |
| **Application** | **Timing:** | Foliar | | **Rate – (g/ha):** 25-150 |
| **Crops** | **Main Pests** | | | |
| Cereals, Cotton, Rape | n.a. | | | |
| **Main Mixture Partners :** ethephon, chlormequat, prohexadione-calcium, 2-chloroethylphosphonic acid, metalaxyl, bacillus-cereus, metconazole | | | | | | |
| **Recent History:**  Plant growth regulator used to reduce vegetative growth in cotton, whilst improving boll retention and maturity. Mepiquat inhibits the metabolic action of gibberellic acid. Also used in mixtures to reduce elongation and help prevent lodging in cereals, and to prevent sprouting on some vegetable crops. Label changes in the US have benefited use on cotton. In 2008 Nufarm acquired the mepiquat-based plant growth regulators Mepex and Mepex Gin Out from DuPont. Re-registered in the EU in 2009 with approval lasting until the end of February 2019. One of several products affected by the Brazilian ‘equivalence’ generic pesticide registration system, whereby generic products are given priority in the registration process, leading to increased competition in the domestic market, and consequently lower prices. | | | | | | |

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| **Mepronil** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | | <10 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Kumiai (Basitac) | None | | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | | **Rate – (g/ha):** 900-12000 |
| **Crops** | **Main Pests** | | | |
| Rice, F&V | A wide range of diseases | | | |
| **Main Mixture Partners :** iminoctadine, tricyclazole | | | | | | |
| **Recent History:**  Broad-spectrum benzanilide fungicide of minor commercial importance. The leading market is against sheath blight on rice. Additional sales are also made for the control of rusts on fruit, and as a seed and soil treatment for the control of various damping off diseases in vegetables. Not re-registered in the EU. | | | | | | |

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| **Meptyldinocap** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Karathane) | Gowan | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 210 |
| **Crops** | **Main Pests** | | |
| Vines, F&V | Powdery mildew | | |
| **Recent History:**  A single isomer form of dinocap, which is made up of 6 isomers. Contact dinitrophenol fungicide with limited penetrant activity providing protectant, curative and eradicant control of powdery mildews. Acts as an uncoupler of oxidative phosphorylation, upsetting the electrochemical balance of the cell and preventing the formation of energy-rich ATP. Useful resistance management tool, considered to present low resistance risk. Registrations achieved in Italy, the UK, Romania and Chile in 2007 under the name Karathane Star. Approved in Italy in 2010 as Karamat M for the control of powdery mildew on strawberries, melons and cucurbits. Gowan develop and market the product for use on fruit and vines in the US and Canadian markets. EU approval has been extended until April 2025. | | | | | |

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| **Mesosulfuron** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | | 215 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Bayer (Sigma, Osprey, Atlantis) | None | | | |
| **Application** | **Timing:** | Post-emergence | | **Rate – (g/ha):** 15 |
| **Crops** | **Main Pests** | | | |
| Cereals, Non-crop | Grass and some broadleaf weeds | | | |
| **Main Mixture Partners :** iodosulfuron, propoxycarbazone | | | | | | |
| **Recent History:**  Developed by Aventis and now part of the Bayer portfolio. Introduced in 2002, mainly in mixtures with iodosulfuron in combination with the safener mefenpyr-diethyl as Atlantis. Main usage is for wild oat and *Phalaris* (canary grass) control in wheat, also suppression of brome and annual ryegrass. Has gained significant market share in the European wild oat control sector, with the product being widely used in France, the UK, Germany and Italy. Rimfire, a combination with propoxycarbazone, has also been introduced. EU approval has been extended until 2032. | | | | | | |

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| **Mesotrione** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | | 650 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| Syngenta (Callisto) |  | | | |
| **Application** | **Timing:** | Pre- and early post- emergence | | **Rate – (g/ha):** 70-225 |
| **Crops** | **Main Pests** | | | |
| Maize, Rice, Cereals, Sugar cane | Broadleaved weeds | | | |
| **Main Mixture Partners :**  atrazine, s-metolachlor, terbuthylazine, dicamba, rimsulfuron, pyraclonil, flucetosulfuron, bicyclopyrone, glyphosate, nicosulfuron | | | | | | |
| **Recent History:**  Benzoylcyclohexanedione herbicide active by inhibition of 4-hydroxyphenyl pyruvate dehydrogenase in the carotenoid biosynthesis pathway. Has been introduced in the USA in mixtures with s-metolachlor (Lumax) and atrazine (Luxar) to counter the uptake of Roundup Ready maize and falling glyphosate prices, with these products offering three different modes of action for weed control in maize. Halex GT, a combination with glyphosate and s-metolachlor, was introduced in 2007 for use on glyphosate-tolerant corn. Bayer and Syngenta are co-developing HPPD tolerant soybeans, with an application for use on the trait submitted to authorities in the US and Canada in 2013. Other combination products include Acuron (atrazine, mesotrione, s-metalochlor and bicyclopyrone) for use on maize in the US and Canada. Has also been introduced as Broadworks in the USA for use on tree nuts, stone fruit and citrus, the first HPPD inhibitor approved for use on these crops in the country. DuPont has access to mesotrione for the development of mixtures for use on maize and sugarcane, with Revulin Q (nicosulfuron and mesotrione) introduced in 2015. In 2016 Arysta launched Desperado for use on maize in Ukraine. Callisto Plus, a combination with dicamba, was approved for use in France in 2016. Approved in the EU until the end of May 2032. In 2017 Nortox’s Meostriona Nortoz (mesotrione) was approved by Brazilian authorities for use on maize and sugar cane. | | | | | | |

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| **Metaflumizone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 85 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Albird), Nihon Nohyaku (Alverde, Axel) |  | | |
| **Application** | **Timing**: | Foliar | **Rate – (g/ha):** 56-224 |
| **Crops** | **Main Pests** | | |
| Non-crop, F&V | Lepidoptera and Coleoptera | | |
| Cotton, soybean, sugar cane, maize | Various pests | | |
| **Main Mixture Partners :** amitraz | | | | | |
| **Recent History:**  Semicarbazone insecticide co-developed by Nihon Nohyaku and BASF, offering a new mode of action: blocking sodium channels in the insect’s nervous system. Well suited for use in Integrated Pest Management and Insecticide Resistance Management programmes. Effective in the control of Colorado beetle on potatoes and potential in cotton for the control of Lygus bugs, the pests reportedly a problem on *B.t.* cotton. The product has been granted EU annex 1 approval with approval until the end of December 2024. Has been registered in a number of country markets, including Germany in 2007; Austria, Colombia, Indonesia, Malaysia and the USA in 2008; and Chile, Greece and Italy in 2009. Also used in the USA for non-crop uses to control fire ants and as Siesta for use on turf and ornamentals. Globally developed by Fort Dodge Animal Health for use as a topical spot treatment and launched in 2007 in EU and US for cats as ProMeris and for dogs as ProMeris Duo in a mixture with amitraz. BASF's Siesta Granular Ant Bait gained approval for use in Australia during 2016. In 2017 Brazilian authorities approved BASF’s Verismo (metaflumizone) for control of a range of pests on soybean, maize, cotton, sugar cane, coffee and citrus. | | | | | |

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| **Metalaxyl** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Phenylamide | | 340 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:**  Rallis, UPL, Sipcam, IQV, Punjab Chemicals, Meghmani | | | | **Structure** | |
| Syngenta (Ridomil) |
| **Application** | **Timing:** | Foliar, Soil,  Seed treatment | | **Rate – (g/ha):** 500-1200 |
| **Crops** | **Main Pests** | | | |
| Potato | Potato blight | | | |
| Vine | Downy mildew | | | |
| F&V, Maize, Cereals, Soybean | A wide range of diseases | | | |
| **Main Mixture Partners :**  fludioxonil, mancozeb, folpet, copper-oxychloride, fluazinam, copper-hydroxide, zineb, mepiquat-chloride, chlormequat-chloride, chlorothalonil, difenoconazole, ipconazole, ethaboxam, fluxapyroxad, pyraclostrobin | | | | | | |
| **Recent History:**  Fungicide for control for the control of late blight (*Phytophthora infestans*) of potatoes and downy mildew (*Plasmopara viticola*) of grapes, with other applications on various crops. Now largely replaced by a single active isomer formulation, metalaxyl-m (also known as mefenoxam). The product has uses via both foliar and soil application, although is now more widely used in seed treatments, mainly for maize, sorghum and sunflower, primarily in combination with other products, notably metalaxyl-m with thiamethoxam, azoxystrobin and difenoconazole and sedaxane. Other partner products include tebuconazole and prothioconazole. Also part of Valent USA’s Intego Suite System seed treatment for soybeans, with ethaboxam, clothianidin and ipconazole. In 2015 BASF received approval for Obvius (metalaxyl, fluxapyroxad and pyraclostrobin) for pulse, podded vegetables and canola in the USA. Has gained EU re-registration with approval until the end of June 2020. In 2016 BASF launched Insure Pulse and Syngenta launched the seed treatment Visivio in Canada. Also in 2016, Arysta introduced Rancona V PD (ipconazole, carboxin and metalaxyl) in the USA. Constituent component of several seed treatment launches in 2017. | | | | | | |

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| **Metaldehyde** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 50 | 1945 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Lonza (Meta) | Amvac | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice, Cereals, Rape, Cotton | Slugs and Snails | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Molluscicide applied by pellet directly to soil, sold by many companies. Sales are very dependent on wet weather and the previous cropping programme, both of which can result in high slug populations. Mainly a European product used particularly on rape and potatoes and on fallow land to prevent slug build up. Has been re-registered in the EU with approval extended until the end of May 2021. In 2002 reduced rate formulations for multiple applications were introduced. All uses were cancelled in Brazil in 2006; however it was approved for household and public health uses and as a wood preservative in 2008. In 2010 Certis introduced the slug pellet product MetaPads in the UK. The Netherlands-based seed coating company Incotec have an agreement to develop, register and market rice seeds coated with the active ingredient for control of the invasive golden-apple snail in Asia. Amvac has introduced the product as Deadline GT in the USA. In 2016 Lonza entered into an agreement with Nulandis under which Nulandis will distribute Lonza’s Axcela (metaldehyde) molluscicide for agricultural applications in South Africa. | | | | | |

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| **Metam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 125 | 1956 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Vapam) | Taminco, Nufarm, Adama, Amvac | | |
| **Application** | **Timing:** | Fumigant | **Rate – (g/ha):** 200000 |
| **Crops** | **Main Pests** | | |
| Potato | Nematodes | | |
| F&V, Plantation crops | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity soil fumigant. Precursor of methyl isothiocyanate, active against fungi, worms, weeds and insects. Amvac acquired Zeneca’s North American metam business in 1996; BASF divested their interest in this product and other soil treatments to Agro-Kanesho in 2004. Metam potassium and metam sodium have been accepted for re-registration in the US. Has received re-registration in the EU with approval extended until the end of June 2022. Main usage is for nematode control, but at a high rate of application. | | | | | |

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| **Metamifop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | <10 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FarmHannong (Metamifop 100) | None | | |
| **Application** | **Timing:** | 0-6 leaf stage on barnyard grass | **Rate – (g/ha):** 100-200 |
| **Crops** | **Main Pests** | | |
| Maize, Rice | Grass weeds | | |
| **Recent History:**  Developed jointly by Dongbu (now FarmHannong) and the Korea Research Institute of Chemical Technology. FMC has an agreement to market the product in China, Indonesia, the Philippines, India, Sri Lanka and Pakistan. In 2017 Farm Hannong received Malaysian registration for Pyzero (metamifop 10%). Since its launch metamifop has been introduced into ten countries: Cambodia, China, [Colombia](https://agrow.agribusinessintelligence.informa.com/AG027861/Farm-Hannong-receives-Colombian-OK-for-metamifop), Ecuador, Indonesia, Japan, Malaysia, Philippines, Sri Lanka, Vietnam and Thailand. | | | | | |

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| **Metamitron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 115 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Goltix) | Gharda, UPL, Phytorus, Tagros, Barclay, Punjab Chemicals, Huapont Nutrichem | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence, Post-emergence | **Rate – (g/ha):** 700-3500 |
| **Crops** | **Main Pests** | | |
| Sugarbeet | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** phenmedipham, ethofumesate, lenacil, chlorpropham | | | | | |
| **Recent History:**  Long-standing leader of the sugarbeet herbicide market, benefiting from a broad spectrum of activity and wide window of application. The product is now subject to significant generic competition and sales have also been impacted by the downturn in EU sugarbeet production. Worldwide rights to the product were divested by Bayer to Adama following the acquisition of Aventis. Adama already had a generic position with metamitron which had been enhanced by the purchase of Feinchemie Schwebda in 2002. Achieved re-registration in the EU with approval extended until the end of August 2022. Adama’s Brevis, a fruit thinner for use on apple and pear trees, was initially launched in Serbia in 2013 and has since been introduced in Greece, Italy, France and Belgium. | | | | | |

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| **Metazachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 165 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Butisan) | Adama | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 750-1750 |
| **Crops** | **Main Pests** | | |
| Rape, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** quinmerac, clomazone, imazamox | | | | | |
| **Recent History:**  Leading herbicide for grass and broadleaved weed control in European winter and spring oilseed rape. Some sales are also obtained in fruit and vegetables. The product benefits from a broad spectrum of activity, a wide window of application and limited generic competition. Usage in mixtures with quinmerac as Novall in France, Butisan Top in Germany, Katamaran in the UK and Butisan Star in East European markets have boosted sales. Also utilised in mixtures with clomazone, and with quinmerac and imazamox as Clearfield Vantiga for use on Clearfield oilseed rape varieties in Germany. EU re-registration has been achieved, with approval extended until the end of July 2021. In 2017 Butisan was approved in Australia for use on Canola. | | | | | |

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| **Metazosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Sulfonylurea | <30 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Altair) | None | | |
| **Application** | **Timing:** | Submerged rice | **Rate – (g/ha):** 60-120 |
| **Crops** | **Main Pests** | | |
| Rice | Annual and perennial weeds | | |
| **Main Mixture Partners:** cafenstrole, daimuron, | | | | | |
| **Recent History:**  Developed by Nissan as NC 620. Introduced in South Korea in 2012 and Japan in 2013. Also under development for introduction in China. In 2012 Nissan opened a new production facility for the product in Sanyo-Onoda. | | | | | |

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| **Metconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Triazole | 180 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Caramba, Twinline) | Kureha, Rallis | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 90 |
| **Crops** | **Main Pests** | | |
| Cereals | Brown rust, Yellow rust, *Septoria* leaf spot, *Fusarium* | | |
| Maize, Rape, Soybean | Range of diseases | | |
| **Main Mixture Partners :** clothianidin, metalaxyl, pyraclostrobin, epoxiconazole | | | | | |
| **Recent History:**  Highly active triazole fungicide, co-developed by Kureha and Shell (now BASF), which achieves strong sales in the West European cereal and oilseed rape sectors. BASF has exclusive rights to foliar uses in North America for use on small grain cereals, soybeans, sugarbeet and cotton. Also finds usage in mixtures, including with pyraclostrobin as Headline AMP mixture for use on maize and with epoxiconazole as Osirirs from Bayer for use on cereals in Italy. Valent USA has introduced the seed treatments Metlock, a solo formulation for corn and cotton, and with clothianidin and metalaxyl as Nipsit Suite for sugarbeet and cereals. BASF’s Headline AMP, a mixture with pyraclostrobin, gained Canadian approval in 2016 for use on maize and small grain cereals. Has gained EU re-registration with approval extended until the end of April 2018. | | | | | |

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| **Methabenzthiazuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Tribunil) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 1500-5000 |
| **Crops** | **Main Pests** | | |
| F&V, Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Ageing cross-spectrum urea cereal herbicide, now of declining importance in the sector. The product has not been accepted for Annex 1 re-registration and left the EU market in 2007. In 2014 the German agricultural distribution company Stefes acquired the Tribunil trademark from Bayer for use in New Zealand on wheat, peas, a range of vegetables and potatoes. Stefes historically supplied Bayer New Zealand with the product. | | | | | |

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| **Methamidophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 40 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Tamaron) | Meghmani, Chinese companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 280-1100 |
| **Crops** | **Main Pests** | | |
| F&V, Rice, Maize, Soybean | A wide range of insects and mites | | |
| Potato | Colorado beetles, Leaf hoppers, Nematodes, Aphid | | |  | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity organophosphorus insecticide, now the subject of use restrictions and regulatory review, hence future potential in developed markets is limited. A number of labels were voluntarily cancelled in the USA in 1997. Has not been re-registered in the EU. Banned in Thailand in 2003 and Nicaragua in 2009. Following the phase out of the use on cotton in 2007, the US EPA issued a cancellation order on all products based on methamidophos in 2009. Usage in Brazil was phased out by mid-2012. Has also received bans in New Zealand and Paraguay in 2013 and then in Argentina during 2016. The a.i. is being phased out in Brazil. | | | | | |

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| **Methidathion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 40 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Supracide) | Adama, Gowan | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-1500 |
| **Crops** | **Main Pests** | | |
| Plantation crops, F&V, Pome fruit | A wide range of insects and mites. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Non-systemic insecticide with both contact and stomach poison activity, particularly useful for codling moth control in intensive fruit orchards, and against scale insects in citrus. Re-registration of some minor uses has not been supported, and the product has not been re-registered in the EU. Although it was accepted for re-registration in the USA, the US EPA cancelled all product registrations following the requests from Gowan and Syngenta in 2010, with distribution of existing stock ending in 2014. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits, with these measures to lead to an eventual ban in the country. | | | | | |

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| **Methiocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 33 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Mesurol, Draza) |  | | |
| **Application** | **Timing:** | Seed treatment, Soil applied | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Maize, F&V, Vine, Cereals | Slugs and molluscs | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Molluscicide for use on a wide range of crops. Sales are dependent on weather and cropping programme, both of which can promote slug and snail populations. Also used as a maize seed dressing for fruit fly control. The product also offers control of a number of insect and mite species in a range of crops. All uses on food and feed crops have been cancelled in Australia. Re-registered in the EU in 2007, however European registration for usage as a molluscicide was cancelled in 2014, with existing stocks used until September 2015. | | | | | |

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| **Methomyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 240 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Lannate) | Adama, BASF, Sinon, Chinese companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 125-8000 |
| **Crops** | **Main Pests** | | |
| Soybean, Maize | Corn earworm, Fall armyworm, Stink bug, many others | | |
| F&V, Cotton | A wide range of insects and nematodes | | |
| **Main Mixture Partners :** cypermethrin, endosulfan | | | | | |
| **Recent History:**  Broad-spectrum commodity insecticide with a wide range of crop outlets. Received re-registration in the EU in 2009. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits, and revoked registrations for the product, with these measures to lead to an eventual ban in the country. An important part of DuPont’s lepidoptera control offering along with indoxacarb and chlorantraniliprole. In recent years DuPont has reduced production costs by consolidating production in Texas and improving manufacturing efficiency. DuPont maintains key country registrations and limits labels to major crops. | | | | | |

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| **Methoxyfenozide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other IGR | 130 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences  (Intrepid, Runner, Prodigy) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 20 – 300 |
| **Crops** | **Main Pests** | | |
| Soybean, F&V, Vine, Pome fruit | Lepidoptera | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Moult inhibiting insect growth regulator (Ecdysone inhibition) for the control of lepidopteran larvae on fruit and cotton, acquired as part of the Rohm & Haas purchase. Introduced in Latin America in 1999 and the USA in 2000. The product has been licensed to Bayer in European markets. Has received Annex 1 approval in the EU until the end of June 2018 and has been introduced in Europe on vine, pome fruit, stone fruit and citrus. The product was introduced in the UK (2003) and Spain (2005) by Bayer as Runner, and also in Poland, followed by further EU introductions for use on fruit and vines. | | | | | |

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| **Methyl arsonic acid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | 40 | 1955 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| KMG Chemicals (Daconate) | Luxembourg, Dow AgroSciences, Ancom | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 840-4500 |
| **Crops** | **Main Pests** | | |
| Sugarcane, Cotton | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Both the mono-sodium salt (MSMA) and di-sodium salt (DSMA) of methyl arsonic acid are marketed. MSMA is the larger product, at one time a major herbicide in cotton, also used on sugarcane and in orchards. The di-sodium salt, DSMA, although also used on cotton, finds more significant sales on turf. KMG Chemicals acquired the rights to the product on the formation of Syngenta in 2000 and started a new plant in Matamoros, Mexico in 2001. MSMA has not been re-registered in the EU, and both MSMA and DSMA have been deemed ineligible for re-registration in the USA. Main market for the product is sugarcane in Brazil. | | | | | |

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| **Methyl bromide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 40 | 1932 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arkema (Brom-O-Gas) | Arysta LifeScience, Albemarle, Dead Sea Bromine | | |
| **Application** | **Timing:** | Post-harvest | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V | Insects, Nematodes, Diseases and Weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Introduced primarily as an insecticidal fumigant for use against pests of stored products, and still widely used for stored products, space and soil fumigation, although now subject to regulatory concerns. Regulatory action has resulted in a phased withdrawal of the product from all crop markets on a global basis, as agreed in the Montreal protocol. Some countries, notably the USA, have negotiated an extension to current usages of the product, whilst post-harvest contained uses are to continue. In 2015 Chinese authorities banned the product for use on fruit and vegetables, tea, sugarcane and medicinal. Has not been approved for use in the EU. | | | | | |

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| **Methyl isothiocyanate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | <10 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Di-trapex) | None | | |
| **Application** | **Timing:** | Soil applied, Fumigant | **Rate – (g/ha):** 50000-150000 |
| **Crops** | **Main Pests** | | |
| F&V | Disease | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum soil fumigant with activity against nematodes, soil diseases, insects, and weed seeds. Originally an Aventis product, now part of Bayer. Methyl isothiocyanate is a precursor to some of the other leading fumigants. Now of limited commercial importance. Re-registration refused in the EU, with use ending in July 2003. The product finds some usage in industrial settings, including as a biocide in natural gas fracking. | | | | | |

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| **Methylcyclopropene** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 110 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| AgroFresh (SmartFresh) | Syngenta (Invinsa) | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 25 |
| **Crops** | **Main Pests / Action** | | |
| F&V, Ornamentals | To slow post-harvest fruit ripening and prolong shelf life of cut flowers | | |
| Maize, Soybean, Cotton, Cereals, Sunflower, Rice, Rape | Offsets the effects of stress (including heat and drought stress) | | |
| **Recent History:**  Used to slow post-harvest fruit ripening and prolong shelf life of cut flowers (Ethyl Bloc) as well as fruit & vegetables (SmartFresh). Jointly developed by Syngenta and AgroFresh, a former Rohm & Hass and then Dow subsidiary, now part of Boulevard Acquisition Corp, with Dow divesting the majority of its AgroFresh business to Boulevard Acquisition Corporation in 2015. Also marketed as a sprayable formulation for pre-harvest usage to offset the effects of stress on crops (temperature and mild to moderate drought). In Syngenta’s Invinsa, 1-MCP is encased in an alpha-cyclodextrin ‘donut’, this protective coating dissolves on wetting such that the 1-MCP is released to exert its biological effect by competitively inhibiting ethylene receptors. Has received EU approval with approval extended until the end of October 2017. | | | | | |

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| **Metiram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Dithiocarbamate | 50 | 1955 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Polyram) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 960-3200 |
| **Crops** | **Main Pests** | | |
| Vine | Downy mildew, Excoriosis, Black Rot | | |
| Potato | Potato blight | | |
| Pome fruit, F&V | A wide range of diseases | | |
| **Main Mixture Partners :** cymoxanil, pyraclostrobin, ametoctradin | | | | | |
| **Recent History:**  Polymeric EBDC fungicide with a broad spectrum of activity, the main being the control of downy mildew and scab in fruit, especially tomatoes, and downy mildew in vines. Arysta launched the product in a mixture with pyraclostrobin as Cabrio Top for use on tomatoes and watermelons in Vietnam in 2011, and BASF introduced the product in a mixture with ametoctradin as Enervin Top in Italy in 2012. Has received re-registration in the EU with approval extended until the end of January 2018. In 2014 the Canadian Pest Management Regulator Agency (PMRA) proposed to phase out all uses of the product, citing public health and environmental concerns arising from the metabolite ethylene thiourea (ETU). Under registration review in the USA. | | | | | |

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| **Metofluthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical  (Eminence) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Non-crop | Mosquitoes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyrethroid commercialised in Japan and other East Asian countries in 2004 for household use. Received EU approval in 2010. Has also received registrations in the USA, Australia and New Zealand. In 2015 Sumitomo launched SumiPro (metofluthrin and cyphenothrin) in Singapore for the control of flies and mosquitos. | | | | | |

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| **Metolachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 590 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Calibra, Produce, Dual) | Proficol, Tri Chemical, Sipcam, Adama | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 1000-3000 |
| **Crops** | **Main Pests** | | |
| Maize, Soybean, Sunflower, Cotton, Cereals, F&V, Sugarcane | Grasses | | |
| **Main Mixture Partners :**  atrazine, mesotrione, terbuthylazine, prometryn, dicamba, rimsulfuron, metribuzin, flumetsulam, fomesafen, bicyclopyrone | | | | | |
| **Recent History:**  Grass weed herbicide, mainly targeted at maize although also registered for use on a wide range of other crops. Now largely replaced in many markets by s-metolachlor based on the active s-isomer and allowing a 40% reduction in application rates. Sales were affected by the success of herbicide tolerant crops; however the introduction of the resolved product has helped ward off generic competition. The racemic mixture has not been re-registered in the EU, but registration in the USA is still in force. Sales have recently benefited from increasing usage in Lumax, with mesotrione and atrazine on maize. Has also been registered for use on sugarbeet as Sequence in the USA and as Zemax, a mixture with mesotrione, on maize. Monsanto has introduced a branded version, Parrlay, for use on Roundup Ready and Roundup Ready FlexCotton crops in the USA. In 2013 Syngenta significantly expanded its production capacity at its Kaisten, Switzerland plant. In 2014 Cheminova (now part of FMC) launched Statement, a combination with fomesafen for use on soybeans and cotton in the US. In 2015 Syngenta received US EPA approval for Acuron (mesotrione, s-metolachlor and atrazine) for use on herbicide tolerant maize. The following year, Acuron Flexi (bicyclopyrone, mesotrione and s-metolachlor) gained US EPA approval. | | | | | |

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| **Metominostrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <30 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Corporation (Oribright) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice, Soybean | Blast | | |
| **Main Mixture Partners :** ethiprole | | | | | |
| **Recent History:**  Broad-spectrum systemic strobilurin fungicide with preventative and curative activity, developed by Shionogi as SSF-126 and introduced in Japan in 2000 principally for rice blast control as Oribright. Shionogi merged with Aventis in 2001 prior to their acquisition by Bayer. In 2014 Sumitomo Corporation’s subsidiary Summit Agro International acquired the product from Bayer Japan, gaining exclusive worldwide rights except in Japan, where they have been licensed back to Bayer. Summit Agro and Iharabras share the rights to the product in Brazil, where it is to be used for the control of Asian soybean rust. In 2017 Fusao EC (metominostrobin) was launched in Brazil for use on soybean, maize, cotton, rice, wheat and kidney beans. In 2013 Kumiai launched the combination insecticide/fungicide Widepunch Mametsubu containing ethiprole and metominostrobin. | | | | | |

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| **Metosulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Other | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Eclipse, Barko, Tacco) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 15-30 |
| **Crops** | **Main Pests** | | |
| Potato, Maize | Broadleaved weeds | | |
| **Main Mixture Partners :** flufenacet, foramsulfuron | | | | | |
| **Recent History:**  Sulfonamide herbicide for broadleaved weed control (including *Galium*) in cereals first introduced by Dow. The marketing rights to the product were divested to Bayer in 2000. Used in a number of mixtures, particularly in the maize sector, including with flufenacet (as Terrano). Has received re-registration in the EU with approval until the end of April 2021. | | | | | |

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| **Metrafenone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | 45 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Flexity, Vivando) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 75-150 |
| **Crops** | **Main Pests** | | |
| Cereals, Vine | Powdery mildew, eyespot | | |
| **Main Mixture Partners :** fenpropimorph, epoxiconazole | | | | | |
| **Recent History:**  Originally discovered by Cyanamid and developed by BASF as AC 375839. Provides control of two diseases, powdery mildew and eyespot, which are usually treated in isolation. The product was registered in the UK in 2004 and has achieved EU registration. The product is marketed as Flexity for use on cereals and as Vivando for use on grapevines. Approvals have since been expanded to markets outside Europe, including the USA, Turkey, South Korea, Chile and Australia. | | | | | |

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| **Metribuzin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 150 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Sencor) | DuPont (Lexone), Adama, Rallis, Bharat Rasayan, Meghmani, UPL | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 400-1100 |
| **Crops** | **Main Pests** | | |
| Potato, Soybean, Sugarcane, F&V, Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** flufenacet, s-metolachlor, imazethapyr, sulfentrazone, clomazone, chlorimuron-ethyl, flumioxazin | | | | | |
| **Recent History:**  Mature cross-spectrum herbicide. Primary usage is on potatoes followed by soybean, although sales in the soybean sector are down from peak levels due to competition from more recently introduced products and the introduction of herbicide tolerant varieties. Also widely used in mixture formulations. Gained re-registration in the EU in 2007 with approval lasting until the end of July 2018. In 2011 Adama’s metribuzin entered Monsanto’s Roundup Ready Plus program in the USA. Belchim’s Italian subsidiary launched the product in a mixture with clomazone as Metric in Italy in 2012, whilst Bayer introduced Fedor (flufenacet and metribuzin) in Italy in 2013 for use on potatoes. In 2014 DuPont introduced Trivence for soybeans in the USA, also containing chlorimuron-ethyl and flumioxazin. Adama launched Squadron in Canada in 2016. | | | | | |

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| **Metsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | 170 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Ally, Algrip) | IPESA, Adama, Rotam, Atul | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 4-7.5 |
| **Crops** | **Main Pests** | | |
| Cereals, Rice, Sugarcane | Broadleaved weeds | | |
| **Main Mixture Partners :** dicamba, thifensulfuron-methyl, flupyrsulfuron-methyl, fluroxypyr, chlorsulfuron, aminopyralid | | | | | |
| **Recent History:**  Sulfonylurea herbicide for broadleaved weed control, widely used in late season to control difficult perennial weeds in cereals, for protection of both current and follow on crops. The product is now mature and finds use in many mixture formulations. Also used in rice, particularly in East Asian markets outside Japan, although sale and use has been prohibited in China. Has achieved Annex 1 listing in the EU with approval extended until the end of March 2023. In 2002 Adama introduced Valuron for cereals in the USA, whilst DuPont introduced a mixture with dicamba and 2,4-D for use on pastures and rangeland as Cimarron Max. In 2008 Rotam received US EPA approval for Rometsol for use in non-crop, turf and forestry markets. Rotam distribute Agform’s novel agrochemical formulations in Europe, including a soluble granular formulation of metsulfuron-methyl which has been introduced in the UK. In 2010 DuPont gained approval in Canada for the product in a mixture with aminopyralid as Clearview for non-crop and industrial uses. In 2014 Bayer acquired several non-crop herbicides from DuPont in the US, Canada, Mexico, Australia and New Zealand; Escort (metsulfuron) being one of these products. In 2015 DuPont received Canadian approval for Travallas (metsulfuron-methyl, thifensulfuron-methyl and fluroxypyr) for the control of broadleaf weeds in spring wheat, durum wheat and spring barley. In 2017 DuPont divested metsulfuron-methyl to FMC as part of the required measures for the Dow-DuPont merger. | | | | | |

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| **Mevinphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1953 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Phosdrin) | Chinese Companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-500 |
| **Crops** | **Main Pests** | | |
| F&V | A wide range of insects | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Commodity broad-spectrum organophosphorus insecticide. Short persistence allows use on food crops close to harvest. Amvac acquired the global Phosdrin business from BASF in 2001. The product is mature and sales are now in decline. No longer sold in the USA and has not been re-registered in the EU. The product was banned in Australia in 1997; however usage on brassicas was re-instated in 2002. | | | | | |

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| **Milbemectin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural Product | <30 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Milbenock, Koromite) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Plantation crops, F&V, Pome fruit | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Avermectin analogue developed by Sankyo. An important miticide in Japan, and has also introduced in many other Asian and Latin American markets, including Brazil, Colombia, Ecuador, Peru, Taiwan, India and South Korea. An important animal health product sold by both Mitsui Chemicals (following the acquisition of Sankyo) and Novartis for the prevention of canine heartworm. Marketed by Gowan in the USA as Mesa and Ultraflora for use on fruit and ornamentals respectively, with registration achieved in 2003. Introduced in the Netherlands by Sankyo in 2002 for ornamentals under glass, the first EU approval for the product. Developed for registration in Germany by Speiss-Urania and by Sumitomo Corporation for the Australian horticulture market. Achieved full EU approval in 2005 until the end of July 2018, and also approved in Australia. Introduced as Milbeknock in Italy in 2007 for use on apples and strawberries. Belchim gained European distribution rights from Mitsui Chemicals in 2014. | | | | | |

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| **Molinate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <30 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Ordram) | Oxon, Nufarm, Nitrokemia, TRI Chemical | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence,  Post-emergence | **Rate – (g/ha):** 2000-4000 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** pyrazosulfuron-ethyl, bensulfuron-ethyl, azimsulfuron, Simetryn, MCPB | | | | | |
| **Recent History:**  Rice herbicide with a wide window of application. Has not achieved Annex 1 re-registration in the EU. Now a commodity product made by several companies, although sales are in a phase of decline. Usage in the USA was phased out by the end of August 2009. Main market is Japan. | | | | | |

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| **Momfluorothrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 2014 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Non-crop |  | | |
| **Recent History:**  Developed by Sumitomo Chemical as S-1563. Approved in the USA and Canada in 2015 and Australia in 2016. | | | | | |

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| **Monocrotophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 37 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Azodrin) | Adama, Rallis, Dow, Sudarshan, Vantech, Anil, NACL, India Pesticides, UPL, Coromandel, Insecticides India | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 400-1000 |
| **Crops** | **Main Pests** | | |
| Rice | Stem borer | | |
| Plantation crops | A wide range of insects/mites and nematodes | | |
| Cotton | Bollworm complex | | |
| **Main Mixture Partners :** cypermethrin | | | | | |
| **Recent History:**  Widely used commodity organophosphorus insecticide with better miticidal activity than many others in the class. Finds the majority of its sales in the rice and cotton sectors, with the main market being India. Not re-registered in the EU and registrations have also been cancelled in the USA, South Africa and New Zealand. Insecticides India acquired Nocil’s Monocil business in 2011, and in 2012 Crystal Crop Protection acquired Luphos-36 from Cheminova’s Indian subsidiary. | | | | | |

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| **Myclobutanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Triazole | 100 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Systhane, Rally) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 175-1000 |
| **Crops** | **Main Pests** | | |
| Vine | Powdery mildew, Black rot | | |
| F&V, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** quinoxyfen, myclobutanil | | | | | |
| **Recent History:**  Broad-spectrum triazole fungicide for use mainly on vines, apples and fruit & vegetables. The product has been introduced for use on a wide range of crops as well as on turf and ornamentals. Moved to Dow following its acquisition of Rohm & Haas. A more advanced formulation was introduced in the USA in 2004 as Laredo for use on fruit and nut crops, and as a seed treatment for cotton. Has received re-registration in the EU with approval extended until the end of May 2021. | | | | | |

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| **N-6 benzyladenine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| PGR | |  | <10 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical/ Valent (Maxcel, Cylex) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Vines, Apples, Pistachios, Ornamentals |  | | |
| **Main Mixture Partners :** 2,4-D-Amine, gibberellic-acid | | | | | |
| **Recent History:**  Cytokinine type product for use a fruit thinning agent and growth regulator. Gained EU Annex 1 registration in 2011 with approval extended until the end of May 2021. | | | | | |

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| **Napropamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 40 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Devrinol) |  | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 560-6000 |
| **Crops** | **Main Pests** | | |
| Rape, F&V, Plantation crops | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** trifluralin, clomazone, dimethachlor | | | | | |
| **Recent History:**  Mature amide herbicide acquired by UPL from Zeneca in 1997 for markets outside Japan. Major usage in the USA is as a residual soil-incorporated herbicide in many fruit and vegetable crops, whilst in Europe it is marketed for use on oilseed rape often in mixtures with trifluralin or clomazone and dimethachlor (Colzor). Has been re-registered in the EU with approval extended until the end of December 2020. UPL has introduced an advanced formulation, Devrinol DF-XT 50 DF, which reportedly takes longer to break down in ultraviolet light and is designed to double the window of control compared to the original formulation, providing four to six weeks of control under normal weather conditions. | | | | | |

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| **Naptalam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Alanap) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 2000-5500 |
| **Crops** | **Main Pests** | | |
| F&V, Non-crop | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Amide herbicide of minor commercial importance for pre-emergence control of broadleaved weeds in certain vegetables and other niche markets. Not re-registered in the EU and left that market in 2003. Now part of the Arysta LifeScience business following the acquisition of Chemtura by Platform Specialty Products. | | | | | |

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| **Nicosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Sulfonylurea | 220 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Accent, Milagro) | Syngenta, Ishihara, IPESA, Nortox, | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 35 |
| **Crops** | **Main Pests** | | |
| Maize, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** dicamba, diflufenzopyr, bentazone, terbuthylazine, rimsulfuron, metsulfuron-methyl, mesotrione | | | | | |
| **Recent History:**  Sulfonylurea herbicide for broad-spectrum, post-emergence weed control in maize which was developed concurrently by DuPont and Ishihara. Zeneca (now Syngenta) acquired the rights to the product outside East Asia and the USA from Ishihara in 1998. The product was successful in the US maize sector for DuPont, but has suffered due to the uptake of herbicide tolerant varieties. Sales are now well down on peak levels, although usage has been assisted by incorporation in a number of mixture formulations and due to its use in the control glyphosate resistant weeds. DuPont also markets the competing rimsulfuron in Europe. Has received Annex 1 registration in EU and achieved re-registration in the USA. The product has also been introduced by Rotam (as Primero for use on maize in the USA and France) and by Adama (as Ironclad, with rimsulfuron, and as Adapt). DuPont has introduced a mixture with rimsulfuron and metsulfuron-methyl for use on ALS-tolerant sorghum varieties. In 2015 DuPont received registration for Revulin Q (nicosulfuron and mesotrione) in the USA for use on maize, whilst Rotam received registration in France for a water dispersible granule formulation as Templier, also on maize. During 2016 DuPont’s Zest gained US approval for use on sorghum. | | | | | |

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| **Nitenpyram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 35 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Bestguard) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice, F&V | Insects, Brown plant hopper, Aphids, Thrips, Leafhoppers, Whitefly | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Neonicotinoid insecticide for the control of sucking insects in rice, vegetables, tea and fruit. Has also been introduced as Capstar for flea and tick control in dogs and cats (co-developed by Syngenta). Originally developed by Takeda, but now marketed by the Takeda/Sumitomo joint venture. Has not been registered in the EU. | | | | | |

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| **Norflurazon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other - Pyridazine | <30 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tessenderlo Kerley (Zorial) | Amvac | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 1100-4000 |
| **Crops** | **Main Pests** | | |
| F&V, Pome fruit, Vine | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum pre-emergence herbicide mainly used on fruit and vegetables. At one time a leading product in the cotton sector, but now of far less significance. The product has not been re-registered in the EU and left that market in 2003. Amvac acquired the product for use on cranberries in the USA (Evital) in 2002. In 2015 Tessenderlo Kerley acquired Syngenta’s norflurazon assets, including trade names, registrations and knowhow. | | | | | |

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| **Novaluron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 80 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Rimon) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cotton, Soybean, Ornamentals, F&V | Lepidoptera, Whitefly (Diptera), Agromyzid leaf miners (Coleoptera) | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Insect growth regulator developed by Isagro and acquired by Adama for final development and introduction, representing Adama’s first proprietary product. First introduced in Latin America and now launched in several other country markets on a wide range of crops. Granted OP replacement status by the EPA in 2004. Chemtura (now Arysta LifeScience) are the exclusive marketers of the product in the USA as Diamond. The product has been phased out in the EU following Adama’s decision to withdraw approvals in 2012. Gained US approval in 2015. In 2016 Adama’s Cormoran (novaluron, acetamiprid) was approved in Australia for use on apples and pears. In 2017 Adama’s Voraz (methomyl, novaluron) was granted an extension by the Brazilian authorities for use on tomatoes, millet, sorghum, coconuts and palm oil. | | | | | |

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| **Noviflumuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | <10 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences  (Recruit) | None | | |
| **Application** | **Timing:** | Containerized bait for use in ground or above ground Sentricon® stations | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Non-crop | Subterranean Termites 0.5% bait matrix. Activity also demonstrated on ants, cockroaches, flies and fleas. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Insect growth regulator, used for enhanced termite control in the Sentricon Colony Elimination System. Noviflumuron is of greater potency, has faster activity, and a wider spectrum of control than hexaflumuron, the active ingredient it replaced in the Sentricon system. Dow’s Recruit HD Termite Bait was approved for use in Canada during 2016. | | | | | |

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| **Omethoate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 45 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Folimat, Le-mat) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 250-1200 |
| **Crops** | **Main Pests** | | |
| Rice, F&V, Rape, Cotton, Sugarcane, Cereals, Potato | Mites, Brown plant hopper, Green leaf hopper, Other leaf hoppers, White backed plant hopper, Boll weevil, Thrips, Whitefly, Aphid, Wheat bulb fly | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus insecticide with a wide range of crop applications. Arysta acquired the product from Bayer in 2005. Usage in major row crops is now in decline, with the product coming under regulatory scrutiny, not being re-registered in the EU or in the USA. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits, and have revoked registrations for the product, with these measures to lead to an eventual ban in the country. New Zealand authorities cancelled registration of the product in 2013. A phase out of omethoate in Australia for all food crops commenced in 2017 with the eventual ban to be imposed some time in 2018. | | | | | |

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| **Orbencarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Lanray) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 3000-7500 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Thiocarbamate herbicide for pre-emergence control of grass weeds. Not re-registered in the EU and left that market in 2003. | | | | | |

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| **Orthosulfamuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS-Other ALS | <10 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Kelion, Strada, Pivot) | None | | |
| **Application** | **Timing:** | Pre- and Early / Mid Post-emergence | **Rate – (g/ha):** 40-75 |
| **Crops** | **Main Pests** | | |
| Rice | Sedges, Broadleaf and Grass weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Early post emergence sulfonylurea herbicide for the control of most weeds of rice. Launched in the USA and Colombia in 2007. In 2011 Isagro transferred the assets of the product to ISEM, a joint venture set up between Isagro and Chemtura, with Nihon Nohyaku subsequently acquiring the product from ISEM in 2013. The product has now received approvals in a number of country markets, notably USA, Brazil, EU, Cuba, South Korea, Bangladesh, China, Pakistan, Sri Lanka, Vietnam, India, Malaysia, Egypt, Turkey and Ivory Coast. In 2014 Nichino America gained the sole US distribution rights to the Strada rice herbicide portfolio. | | | | | |

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| **Orysastrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <30 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Arashi) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Sheath blight, Rice blast | | |
| **Main Mixture Partners :** fipronil, clothianidin | | | | | |
| **Recent History:**  Introduced in Japan and South Korea in 2007. Utilised in many mixture formulations in Japan where the product has been well received for use on rice, notably in mixtures for nursery box application with fipronil as Arashi Prince and clothianidin as Arashi Dantotsu. Has not been approved in the EU. | | | | | |

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| **Oryzalin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | <30 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Surflan) | Punjab Chemicals | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 1000-2000 |
| **Crops** | **Main Pests** | | |
| F&V, Turf, Pome fruit, Vine | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diuron | | | | | |
| **Recent History:**  Dinitroaniline herbicide for pre-emergence control of grass and some broadleaved weeds in fruit and vines. Re-registered in the EU with approval extended until the end of May 2021. Worldwide rights outside Switzerland and the EU were acquired by UPL in 2003. | | | | | |

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| **Oxadiargyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | <10 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Raft, Topstar) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 50-200 |
| **Crops** | **Main Pests** | | |
| Rice, F&V, Sunflower | Grasses | | |
| **Main Mixture Partners :** aclonifen | | | | | |
| **Recent History:**  Herbicide for pre-emergence grass weed control in rice, sunflower and vegetable crops. Structural analogue of oxadiazon and used in similar markets. Developed and introduced by Aventis and now part of the Bayer portfolio. The main target market for the product is rice in East Asia (including China and India) and Latin America, particularly in developing markets. Introduced in 2002 in Japan for use on turf as Fenax flowable. Introduced in a mixture with aclonifen for use on sunflowers in France as Carioca in 2004. A further mixture with aclonifen, Opalo, was launched in Spain in 2009 for use on tomatoes, tobacco, onions, garlic and artichokes. Has not been re-registered in the EU. | | | | | |

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| **Oxadiazon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | 50 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Ronstar) | Adama | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 240-7500 |
| **Crops** | **Main Pests** | | |
| Rice, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** oxyfluorfen, napropamide | | | | | |
| **Recent History:**  Herbicide for pre- and early post-emergence control of annual grass and broadleaved weeds in rice, also with applications in a range of other crops. Developed and introduced by Aventis and now part of the Bayer portfolio. In 2003 UHS introduced a granular formulation for use on ornamentals in a mixture with oxyfluorfen as Laser, and with napropamide as Prepair. Re-registration in the EU has been achieved with approval being extended until the end of December 2018. Adama launched a generic version in the USA in 2004 for use on golf courses, parks and public areas. | | | | | |

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| **Oxadixyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Phenylamide | <10 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Sandofan) | None | | |
| **Application** | **Timing:** | Foliar, Soil, Seed treatment | **Rate – (g/ha):** 100-300 |
| **Crops** | **Main Pests** | | |
| F&V, Cereals | A wide range of diseases. | | |
| **Main Mixture Partners :** mancozeb, cymoxanil, folpet | | | | | |
| **Recent History:**  Phenylamide fungicide that has suffered from resistance development and is now almost exclusively used in mixture formulations, especially with cymoxanil, folpet and the EBDCs. Has not been re-registered in the EU, and all usages were cancelled in the USA in 2003. | | | | | |

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| **Oxamyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 40 | 1973 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Vydate) | None | | |
| **Application** | **Timing:** | Foliar, Soil applied | **Rate – (g/ha):** 140-1125 |
| **Crops** | **Main Pests** | | |
| Potato | Aphid, Colorado beetles, Leaf hoppers, Nematodes | | |
| F&V | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Insecticide/nematicide with miticidal activity against chewing and sucking pests with several crop outlets. Main markets are on potatoes and vegetables for the control of Colorado beetle and aphids. Maintains a steady sales performance and now a part of DuPont’s lepidoptera control strategy with methomyl, indoxacarb and chlorantraniliprole. Has received re-registration in the EU, with an extension granted to February 2018. | | | | | |

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| **Oxasulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <10 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Dynam) | **None** | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 60-90 |
| **Crops** | **Main Pests** | | |
| Soybean | Broadleaf weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Introduced in Latin America, the EU and USA, but has not made a significant commercial impact. | | | | | |

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| **Oxathiapiprolin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - piperidinyl-thiazole-isoxazoline | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Zorvec) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 2.8-22.8 |
| **Crops** | **Main Pests** | | |
| F&V | Phytophthora, Downy mildew | | |
| Potato | Late blight | | |  | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  An Oomycete control product with a new mode of action, developed as DPX-QGU42. Reportedly active at lower rates of application than existing Oomycete products. US registration gained in 2015, with registrations in several other countries, including China, Mexico, Australia and New Zealand, expected to follow in 2016. In 2013 DuPont granted Syngenta access to oxathiapiprolin via a worldwide license to develop products including exclusive rights for foliar and soil uses on all crops in the USA and Canada. Marketed by Syngenta as Orondis. Approved in the EU in 2017. | | | | | |

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| **Oxaziclomefone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <30 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Samurai, Homerun) | Zennoh | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 25-80 |
| **Crops** | **Main Pests** | | |
| Rice | Grass weeds | | |
| **Main Mixture Partners :** bensulfuron-methyl, clomeprop, pyraclonil, pyrazosulfuron-ethyl, benzobicyclon | | | | | |
| **Recent History:**  Co-developed by Aventis and Zennoh as MY-100. Introduced in Japan in 2001. Now part of the Bayer portfolio following the acquisition of Aventis. Utilised in ‘one shot’ rice herbicides in Japan - the product’s key market – primarily in a mixture with bensulfuron-methyl and clomeprop as Mr Homerun. Other mixture products launched in Japan include Samurai (Nihon Nohyaku), Patful (Kumiai), Tredy (Nissan) and Thoroughbred (Takeda). Now introduced throughout Asia, including Korea, China, Thailand and Vietnam. In 2012 Nissan introduced the product in a mixture with pyraclonil, pyrazosulfuron-ethyl and benzobicyclon as Sirius Exa in Japan. | | | | | |

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| **Oxine-copper** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Inorganic | <30 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Quinolate) | Agro-Kanesho, Sinon | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cereals, F&V | Bunt, *Fusarium*, Glume blotch, Dark leaf Spot, Stem rot, Damping off | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  The basis of a wide range of seed treatments and used in many mixture formulations, particularly in the West European market. Main use is as a cereal seed treatment for the control of bunt (*Tilletia caries*) and glume blotch resulting from *Septoria nodorum* infection. Not re-registered for use as a fumigant in the EU. | | | | | |

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| **Oxolinic acid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Starner) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** 300-600 |
| **Crops** | **Main Pests** | | |
| F&V, Rice, Potato | Bacterial diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Bactericide active against soft rot (caused by a complex of pathogens including *Erwinia*) and also *Pseudomonas* infections in rice and vegetables. Widely used as an antibiotic in aquaculture. | | | | | |

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| **Oxpoconazole fumarate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other Azole | <10 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| OAT Agrio (All-shine) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Co-developed by Ube and OAT Agrio as UBF-910 and introduced in Japan in May 2000, although has yet to make a significant commercial impact. Has not achieved approval for use in the EU. | | | | | |

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| **Oxydemeton- methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1959 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Oxydemeton-M, Metasystox R) | Bharat, Sudarshan, Gowan | | |
| **Application** | **Timing:** | Soil,  Foliar | **Rate – (g/ha):** 140-840 |
| **Crops** | **Main Pests** | | |
| F&V, Cotton, Plantation crops | Aphids, Insects, Mites | | |
| **Main Mixture Partners :** beta-cyfluthrin | | | | | |
| **Recent History:**  Broad-spectrum insecticide of relatively high toxicity, offering control of sucking pests on a wide range of crops. Acquired by UPL from Bayer in 2006. A low-cost standard treatment, now limited by regulatory action and not re-registered in the EU, leaving that market in 2007. The product has been approved for re-registration in the USA. | | | | | |

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| **Oxyfluorfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Diphenyl Ether | 150 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nutrichem (Goal) | Adama, Chinese companies | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 135- 2200 |
| **Crops** | **Main Pests** | | |
| F&V, Plantation crops, Peanuts, Rice, Vine, Cereals, Soybean | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** flufenacet | | | | | |
| **Recent History:**  Diphenyl ether herbicide introduced for use on cotton, vines and rice, but now of more significance on fruit & vegetables, particularly in the USA. In 2015 the Chinese company Nutrichem acquired Dow’s oxyfluorfen business, with Dow continuing to distribute herbicides based on the product manufactured by Nutrichem. The US EPA has accepted the product for re-registration following some minor label changes to reduce application rates, and the product has also been re-registered in the EU with a restriction imposed in 2017 for a maximum application rate of 150g a.i./ha/year. | | | | | |

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| **Paclobutrazol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 60 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Bonzi) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 750 |
| **Crops** | **Main Pests** | | |
| F&V, Non-crop, Rape | n.a. | | |
| **Main Mixture Partners :** difenoconazole | | | | | |
| **Recent History:**  Gibberellin inhibitor developed for vegetative growth retardation in ornamentals and fruit trees. Syngenta took back marketing rights from Crompton (Chemtura) in 2002. SePRO acquired Dow’s Profile tree growth regulator business in 2013. Has received re-registration in the EU with approval extended until the end of May 2021. In 2013 the Canadian Pest Management Regulatory Agency (PMRA) proposed the continued registration of the product, on the basis that certain changes to the product label be made. | | | | | |

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| **Paraquat** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Bipyridyl | 610 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Gramoxone) | Sanonda, Red Sun, SinonBaofeng, CAC, Luba, Taoyuan, Xianlong, Yongnong | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence, Harvest aid | **Rate – (g/ha):** 150-1000 |
| **Crops** | **Main Pests** | | |
| Maize, Soybean, F&V, Cotton, Cereals, Rice, Sugarcane, Pome fruit, Potato | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** diquat, diuron, simazine | | | | | |
| **Recent History:**  Non-selective contact herbicide with many crop and non-crop applications. Used as a burn-off treatment for weeds, particularly in plantation crops; as a desiccant in sugarcane, and sunflower; and for potato haulm destruction. Generic competition has been limited. Benefits from its position as a replacement to hand weeding in developing east Asian markets and from its rainfastness. Has not been re-registered in the EU, and currently under registration review in the USA, Canada. Brazilian authorities have ordered a three year phase out commencing in 2017. Registration is an issue in some other markets due to human toxicity, however this has largely been overcome by usage in combination with diquat. Syngenta introduced a new Gramoxone formulation in North America in 2011, Gramoxone SL, which reportedly offers increased mixing compatibility as well as improved handling characteristics. In 2014 China revoked registrations and production licences for aqueous formulations. Nanjing Redsun has received a manufacturing approval for a 20% paraquat water-soluble gel that is indicated as a replacement for the banned aqueous formulations. In 2017 Amvac acquired paraquat from Adama as a condition of the US authorities’ approval of the ChemChina takeover of Syngenta. | | | | | |

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| **Parathion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1947 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC | Indian and Chinese companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 100-2000 |
| **Crops** | **Main Pests** | | |
| Cotton, Rice, F&V | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity organophosphorus insecticide that shows particular activity against a range of soil borne pests as well as sucking and biting insects and mites, and with ovicidal activity against aphids. The product is the subject of regulatory concerns and sales are in decline. Under an agreement between Cheminova (now part of FMC) and the EPA all usages in the USA were phased out in 2003. The product has also been excluded from Annex 1 in the EU and removed from the market in Canada. | | | | | |

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| **Parathion-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 42 | 1947 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC | Indian and Chinese companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 100-2000 |
| **Crops** | **Main Pests** | | |
| Soybean | Corn Rootworm, Cutworm, Armyworm | | |
| Cotton | Bollworm complex, Other lepidoptera, Boll weevil, Aphid, Thrips | | |
| F&V | A range of pests | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity broad-spectrum organophosphorous insecticide. Acts by both contact and oral routes and finds use in a wide variety of crops. Has been the subject of regulatory concerns and has not been re-registered in the EU. All remaining uses of the product were cancelled in the USA in 2010 with the sale and distribution of existing stocks discontinuing in 2012. Also removed from the market in New Zealand and banned in Brazil. Approval of the product has been cancelled in Australia, with all sales and uses in the country phased out in 2013. Brazilian authorities have ordered a three year phase out commencing in 2017. | | | | | |

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| **Pefurazoate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI – Other azole | <10 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Hokko (Healthied) |  | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Bakanae disease, Rice blast | | |
| **Main Mixture Partners :** copper fungicide, fludioxonil, thiram | | | | | |
| **Recent History:**  Narrow spectrum seed treatment that was jointly developed by Ube and Hokko. Used on rice for the prevention of *Fusarium* spp. (bakanae disease) and rice blast. Very unstable in sunlight, a niche product with limited sales. Has not been approved for use in the EU. | | | | | |

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| **Penconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 55 | 1983 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Topas) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 15-30 |
| **Crops** | **Main Pests** | | |
| Vine | Powdery mildew | | |
| Pome fruit, F&V | A range of diseases and mites | | |
| **Main Mixture Partners :** captan, dinocap | | | | | |
| **Recent History:**  One of the more active products for the control of powdery mildew on vines and fruit & vegetables, deriving most of its sales in the European market. Has achieved re-registration in the EU with approval extended until the end of December 2021. Also used in a number of mixture formulations. | | | | | |

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| **Pencycuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | 55 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Monceren, Trotis) | LG Chemical, FarmHannong | | |
| **Application** | **Timing:** | Seed treatment, Foliar | **Rate – (g/ha):** 150-5000 |
| **Crops** | **Main Pests** | | |
| Potato | Black scurf | | |
| F&V | A wide range of diseases | | |
| Rice | Sheath blight | | |
| **Main Mixture Partners :** imidacloprid | | | | | |
| **Recent History:**  Non-systemic specific fungicide for the control of *Rhizoctonia* diseases in a range of crops. At one time a leading product for sheath blight (*Rhizoctonia solani*) control in rice but has lost share to more recent introductions. Used as a seed treatment on cotton, potatoes, and vegetables. Has gained re-registration in the EU with approval extended until the end of May 2021. | | | | | |

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| **Pendimethalin** | **Product Type:** | | **Class:** | | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | | 355 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | | **Structure** | |
| BASF (Prowl, Stomp) | Rallis, Adama, FarmHannong, Meghmani,Ipici, Punjab Chemicals | | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence, Post-emergence | | **Rate – (g/ha):** 560-2250 |
| **Crops** | **Main Pests** | | | |
| Cereals, Plantation crops, F&V, Cotton, Soybean, Maize, Rice, Sunflower, Potato | Grasses, Broadleaved weeds | | | |
| **Main Mixture Partners :** isoproturon, dimethenamid, linuron, metobromuron, flufenacet, pyroxsulam, sulfentrazone, clomazone | | | | | | |
| **Recent History:**  Broad-spectrum herbicide with a wide range of crop applications. Benefits from action against both grass and broadleaf weeds, with a wide window of application from pre-plant incorporation through to post-emergence application (monocot crops only). As such the product is used in many co-formulations, most notably with the imidazolinones. In 2010 Dow introduced the product in a mixture with pyroxsulam as Broadway Sunrise for use on wheat in the UK. Has achieved re-registration in the EU. In 2016 Belchim launched Alcance Sync Tec (clomazone, pendimethalin) in France for use on maize and sorghum. | | | | | | |

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| **Penflufen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 150 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Emesto, EverGol) | None | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Potato | Black Scurf (*Rhizoctonia solani*), Silver Scurf (*Helminthosporium solani*), Dry rot (*Fusarium*) | | |
| Cereals | Root rot (*Rhizoctonia* spp.), Smut | | |
| Rape, Soybean, Cotton | Number of seed-borne pathogens | | |
| **Main Mixture Partners:** prothioconazole, metalaxyl, trifloxystrobin, clothianidin, | | | | | |
| **Recent History:**  Novel pyrazole fungicide for seed treatment in various crops, such as potatoes, canola/oilseed rape, soybeans, corn and cotton. Effective against a number of seed-borne pathogens and features particularly broad action and efficacy against *Rhizoctonia* spp. Contributes to strong seedling development due to its good seed tolerance. First worldwide approval in UK in 2011 as Emesto for use on potatoes. Further approvals received in USA, Canada and Ukraine in 2012. A number of co-formulations have also been introduced; Titan Emesto (penflufen, clothianidin and prothioconazole) in Canada in 2012 for use on potatoes; Emesto Silver (penflufen and prothioconazole) for potatoes; EverGol Prime for cotton; EverGol Energy (penflufen, prothioconazole and metalaxyl) for wheat; and Prosper EverGol (penflufen, trifloxystrobin, metalaxyl and clothianidin) for canola launched in the USA in 2013. EverGol Prime was approved in Australia in 2013 for the control of root rot and smut diseases in wheat and barley. DuPont Pioneer has an agreement to provide EverGol Energy (penflufen, prothioconazole and metalaxyl) as part of its Pioneer Premium Seed Treatment program for use on soybeans in the USA. EU approval has been received with registration currently active until February 2024. Penflufen constitutes part of the triple pack seed treatment for use on pules crops in Canada called Trilex EverGol, released by Bayer in 2017. | | | | | |

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| **Penoxsulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS sulfonamide | 210 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Fencer, Viper, Clipper, Ricer) | None | | |
| **Application** | **Timing:** | Pre- and post-emergence | **Rate – (g/ha):** 10-50 |
| **Crops** | **Main Pests** | | |
| Rice, Turf | Grass, Broadleaf & sedge weeds | | |
| **Main Mixture Partners :** cyhalofop-butyl | | | | | |
| **Recent History:**  Broad spectrum rice herbicide that can be used in most cultivation systems and has been well received since its introduction. Introduced in Italy (as Viper) and the USA in 2005 and in Spain in 2006. Introduced in Japan in 2007 and China in 2009, also registered in several other country markets including Greece, Turkey and Egypt. Has applications on dry seeded, transplanted, and water seeded rice. The product received reduced risk status in the USA in 2003. Has received approval in the EU with registration active until the end of July 2020. | | | | | |

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| **Penthiopyrad** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 60 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Affetto, Aphet / Gaia) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Canola, F&V, Turf | Powdery mildew, *Botrytis*, Rusts, *Rhizoctonia*, Scab, *Septoria* | | |
| **Main Mixture Partners:** chlorothalonil | | | | | |
| **Recent History:**  Carboxamide fungicide developed for use on pome fruit, stone fruits, citrus, tomatoes, cucurbits, ornamentals and turf. Registration was achieved in Japan in 2008 for use on fruit, vegetables and ornamentals as Aphet and for use on turf as Gaia, with commercial introduction in 2009. DuPont hold a license to register and market formulated penthiopyrad products in the Americas, the EU and Australasia, subsequently launching Fontelis, for use on fruit & vegetables, and Vertisan, for use on arable crops (canola, sunflowers, pulses and potatoes) in Canada. Fontelis has also received approvals in the USA and Australia. DuPont has also introduced Vertisan, for cereals, and Treoris, a co-formulation with chlorothalonil for use on wheat, in the UK. Has received registration in the EU with approval currently valid until the end of April 2024. In 2015 Syngenta introduced Velista in the US for use on turf. In 2016 Mitsui introduced Pikatto (penthiopyrad, mepanipyrim) for foliar use on fruit and vegetables. | | | | | |

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| **Pentoxazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | <30 | 1998 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kaken (Wechser) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 150 – 450 |
| **Crops** | **Main Pests** | | |
| Rice | Grass, Sedge and some Broadleaved weeds | | |
| **Main Mixture Partners :**  cumyluron, bensulfuron-methyl, pyriminobac-methyl, bromobutide, bensulfuron-methyl | | | | | |
| **Recent History:**  Long-acting oxazolidinedione herbicide active via PPO inhibition. Used in many ‘one-shot’ mixtures for *Echinochloa* (barnyard grass) control, notably Topgun (pyriminobac-methyl, bromobutide, bensulfuron-methyl and pentoxazone) and Sumitomo’s Hammer Jumbo (propyrisulfuron, pentoxazone) in Japan. Introduced in Japan and registration achieved in Korea in 2001. In 2011 Ishihara gained approval in Japan in a mix with cumyluron and bensulfuron-methyl in the Dohji-guard range. Has not achieved approval for use in the EU. | | | | | |

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| **Permethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 200 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Ambush) | FMC, BASF, Dow, Bilag, Atul, Tagros, Meghmani, Sumitomo Chemical, UPL, Coromandel, Bharat Rasayan, Heranba, Meghmani, Amvac | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 60-450 |
| **Crops** | **Main Pests** | | |
| F&V, Soybean | A wide range of insects | | |
| Maize | Corn root worm, European corn borer, Cutworm, Cornstalk borers, Flea beetle, | | |  | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity pyrethroid with a wide range of outlets. Sales down from peak levels as the market has shifted towards newer generation and resolved products in crop markets. As a result some companies have not supported the re-registration of the product, resulting in its removal from EU markets in 2001. Sumitomo Chemical has introduced Olyset Net, a permethrin-embedded mosquito net for use in Africa, with production levels now exceeding 60 million nets per year. Significant sales are achieved in other non-crop sectors, particularly public health. Deemed eligible for re-registration in the US, providing certain label changes are made. In 2006 Amvac acquired Syngenta’s permethrin product line in the USA, Mexico and Canada including all registration rights, manufacturing and formulation procedures, inventories, customer lists and trademarks in crop and non-crop markets. | | | | | |

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| **Pethoxamid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | <30 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tokuyama/FMC  (Koban, Successor) | None | | |
| **Application** | **Timing:** | Pre- and early post-emergence | **Rate – (g/ha):** 750 -1500 |
| **Crops** | **Main Pests** | | |
| Maize, Rape | Grass (mainly annual) and some broadleaf weeds | | |
| **Main Mixture Partners :**  terbuthylazine, clomazone | | | | | |
| **Recent History:**  Originally discovered by Tokuyama Soda, but developed by Stähler, and introduced in Germany and Austria in 2006. Passed to Cheminova on its purchase of Stähler, now part of FMC following its acquisition of Cheminova. Arysta distribute the product as Somero and in a mixture with terbuthylazine as Bolton Duo in the Czech Republic and Slovakia. Cheminova also introduced Nero, a combination of pethoxamid and clomazone, for use on oilseed rape. Has achieved Annex 1 registration in the EU. | | | | | |

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| **Phenmedipham** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | 80 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Betanal) | Adama, IPiCi, UPL, Griffin, Feinchemie Schwebda | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 285-400 |
| **Crops** | **Main Pests** | | |
| Sugarbeet, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** desmedipham, ethofumesate, metamitron, chloridazon, quinmerac | | | | | |
| **Recent History:**  One of the largest selling sugarbeet herbicides, providing post-emergence control of broadleaved weeds. Now a commodity product. Has received re-registration in the EU until the end of July 2018. | | | | | |

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| **Phenthoate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1961 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan (Elsan) | Sumitomo Chemical, Atul, Coromandel | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 100-1000 |
| **Crops** | **Main Pests** | | |
| Plantation crops, Rice, F&V | Aphid, Thrips, Brown plant hopper, Green leafhopper, Leaf beetle, Leaf miner, Stem borer, Yellow rice borer | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity organophosphorus insecticide of minor importance. Not re-registered in the EU and left the market in 2003. | | | | | |

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| **Phorate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 40 | 1954 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Thimet) | UPL, FMC, Rallis, Pesticides India | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** 450-2700 |
| **Crops** | **Main Pests** | | |
| Cotton, F&V, Cereals, Rice | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** diazinon | | | | | |
| **Recent History:**  Broad-spectrum systemic organophosphorus insecticide used mainly for the control of soil borne pests, especially nematodes and wireworm. Not re-registered in the EU and phased out in Canada in 2007. Amvac acquired BASF’s global phorate business in 2005 followed by that of Aceto and Valent in 2008. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits, with these measures to lead to an eventual ban in the country. Has also been banned in Brazil and New Zealand. Indian authorities have imposed a phase out, leading to an eventual ban by the end of 2020. | | | | | |

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| **Phosalone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Zolone) | Chinese companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 600-1200 |
| **Crops** | **Main Pests** | | |
| Cotton, F&V | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorous insecticide/miticide used in a wide range of crop outlets. The product has come under regulatory restriction in some markets, and has not been re-registered in the EU or in the USA, however tolerances for imported crops in the USA have been maintained. Worldwide rights acquired by Cheminova from Bayer following the acquisition of Aventis, now passed to FMC following its acquisition of Cheminova. | | | | | |

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| **Phosmet** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Imidan) | Inquinosa, Tekchem | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 220-1100 |
| **Crops** | **Main Pests** | | |
| Pome fruit, F&V | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum commodity organophosphorus insecticide, now largely replaced by newer introductions. In 2001 Gowan added ornamentals and vines to their label, and also a claim for snail control. Re-registered in the EU (under certain risk mitigation measures). Brazil issued use restrictions in 2010. | | | | | |

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| **Phosphamidon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1956 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Kinadon) | De-Nocil | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-1000 |
| **Crops** | **Main Pests** | | |
| Rice, F&V | A wide range of insects and mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphate insecticide that shows particularly good activity against aphids. Now a commodity product phased out by Syngenta but manufactured by a wide range of other companies. Not re-registered in the EU, and all registrations have been cancelled in the USA. Banned in Paraguay in 2013. Indian authorities have imposed a phase out, leading to an eventual ban by the end of 2020. | | | | | |

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| **Phoxim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 70 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Chinese companies |  | | |
| **Application** | **Timing:** | Soil applied, Foliar, Post-harvest | **Rate – (g/ha):** 1000-5000 |
| **Crops** | **Main Pests** | | |
| Rice, Plantation crops, Maize, Cotton, Cereals | Aphid, Bollworm, Lepidopteran larvae, Spodoptera, Armyworm, Beetles | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Mature organophosphate insecticide primarily used to control pests in rice, with minor usage in a range of other crops, notably maize and cotton. Also used to control pests in stored crops and in public health where it is marketed under the trade name Baythion. Not registered in the EU, and not marketed in the USA or Canada. Banned in New Zealand in 2013. | | | | | |

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| **Phthalide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 1971 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kureha (Rabcide) | Gharda | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-750 |
| **Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| **Main Mixture Partners :** ferimzone, validamycin, silafluofen, ethiprole | | | | | |
| **Recent History:**  Rice blast fungicide used predominantly in a mixture with ferimzone (adding ear blight activity) as Blasin. | | | | | |

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| **Picarbutrazox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Tetrazolyloxime | - | 2017 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | Structure | |
| Nippon Soda (Pythilock) |  | | |
| **Application** | Timing: | Foliar, Soil | **Rate:** Foliar 50 ppm, Soil 67-200 ppm |
| **Crops** | **Main Pests** | | |
| Vegetables, Rice, Turf, Cereals | Downy mildew, Late blight, Pythium, others | | |
| **Recent History:**  Japanese approval as QuinTect WG was achieved in early 2017 for use on turf, whilst in October 2017 Nippon Soda launched Pythilock (picarbutrazox) in Japan for the control of oomycete diseases such as downy mildews and late blight (Phytophthora infestans) on cucurbits, tomatoes and leafy vegetables. The active ingredient reportedly features translaminar and curative properties, and is the first and only member of the tetrazolyloxime group. Nippon Soda plans to develop the a.i. globally as a foliar spray and seed treatment. US registration decision is anticipated in April 2019. | | | | | |

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| **Picloram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 260 | 1963 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Tordon) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 70-560 |
| **Crops** | **Main Pests** | | |
| Range and pasture, Cereals, Rape, Maize, Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** clopyralid | | | | | |
| **Recent History:**  Persistent herbicide used predominantly in non-crop situations, particularly range and pasture, for the control of annual and perennial broadleaved weeds. Use was extended to sugarcane in Brazil in 2010, although sales in this sector remain limited. The product is belatedly suffering from generic competition now that the cost of manufacture in India and China has come under control, although it remains an important part of the Dow portfolio. Being replaced by Dow in some markets with the patented aminopyralid, which is active at lower application rates. Re-registration in the EU has been achieved until the end of 2018. | | | | | |

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| **Picolinafen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | <10 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Pico, Sniper, Paragon) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 50 – 130 |
| **Crops** | **Main Pests** | | |
| Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** pendimethalin, 2,4-D, imazamethabenz | | | | | |
| **Recent History:**  Post-emergence contact herbicide for use on cereals. Gained its first approvals in Germany and Australia in 2001, followed by the UK, where it is marketed as PicoPro in a mixture with pendimethalin, and in France in 2002 as Celtic, also a mixture with pendimethalin. Approval was achieved in Canada in 2005 where it is sold in mixtures with 2,4-D and imazamethabenz. Positioned to benefit from resistance development to the sulfonylureas and isoproturon. EU approval has been achieved, although the product is yet to make a significant commercial impact. | | | | | |

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| **Picoxystrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 320 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Acanto, Aproach) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 250 |
| **Crops** | **Main Pests** | | |
| Soybean | Asian rust | | |
| Cereals | Brown rust, *Septoria* leaf spot, Net blotch, Leaf blotch | | |
| Maize, Rape | A wide range of diseases | | |
| **Main Mixture Partners :** fenpropidin, propiconazole, hexaconazole, cyproconazole | | | | | |
| **Recent History:**  Reportedly the most systemic of the strobilurins, with a major strength being curative activity against yellow rust as well as good control of *Septoria*, and of net blotch in barley. Syngenta registered the product in most European markets, predominantly for use on barley and apples, some niches where azoxystrobin was not so strong, although commercial potential was held back due to positioning alongside azoxystrobin. In cereals picoxystrobin was positioned as the first in a three spray strategy, complementing azoxystrobin, which is mainly used as a third spray, so maximizing the greening activity and yield benefits of the treatment. In 2006 picoxystrobin passed to DuPont in return for Syngenta gaining access to the insecticide chlorantraniliprole for use in mixtures. Following this, the commercial potential is being more fully exploited by DuPont, with the company introducing the product in a number of additional market sectors resulting in significant sales growth, particularly against Asian rust on soybeans in Brazil. DuPont continues to receive further registrations, notably for Aproach in the USA in 2012 for use on corn, soybeans and wheat, and also in a mixture with cyproconazole in both Argentina and Brazil in 2011 and in Canada in 2012. Has been approved in the EU. In 2017 DuPont launched Vessarya (picoxystrobin, benzovindiflupyr) in Brazil for use on cereals. In 2017 DuPont granted FMC an exclusive licence for rice applications in the EEA, to address the European Commission's concern on product competition for rice blast fungicides. | | | | | |

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| **Pinoxaden** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other (phenylpyrazolin) | 390 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Axial) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 30-70 |
| **Crops** | **Main Pests** | | |
| Cereals | Grass weeds | | |
| **Main Mixture Partners:** fluroxypyr, clodinafop, florasulam, cloquintocet-mexyl | | | | | |
| **Recent History:**  Cereal herbicide which has enjoyed significant sales growth in the sector for post-emergence control of grass weeds. Offers broad control of spring grass weeds including wild oats and rye grasses. Has a good fit in the autumn cereal herbicide sector, a market where Syngenta traditionally had little input. First registrations were achieved in Canada, the USA, UK, Germany and Australia in 2005. Syngenta has also introduced Traxos, a combination with clodinafop-propargyl and cloquintocet-mexyl. Other combination products include with florasulam, as Axial TBC in the USA and as Broadband in Canada for use on wheat and barley; and with fluroxypyr, as Axial Star in the USA and Axial Xtreme in Canada for use on spring and winter wheat and barley. TraxosTwo, also containing clodinafop, 2,4-D ester and fluroxypyr, was launched in Canada in 2015 for the control of annual grass and broadleaf weeds on spring wheat and durum wheat. Syngenta launched a formulation of Axial in Canada in 2012 containing a new built-in adjuvant which reportedly increases uptake when compared to standard crop oil concentrate or methylated seed oil adjuvants, resulting in improved speed of activity. Has achieved registration in the EU with approval currently valid until the end of June 2026. | | | | | |

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| **Pirimicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 45 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Pirimor) | None | | |
| **Application** | **Timing:** | Foliar, Fumigant | **Rate – (g/ha):** 280-560 |
| **Crops** | **Main Pests** | | |
| F&V, Cereals, Pome fruit, Sugarcane | A wide range of insects | | |
| **Main Mixture Partners :** lambda-cyhalothrin, deltamethrin | | | | | |
| **Recent History:**  Mature, specific aphicide used on a wide range of crops, including cereals for the control of foliar and grain feeding aphid species, principally the green peach aphid (*Myzus persicae*). Also has a range of applications in the fruit and vegetable sector, although resistance development has become a factor in some markets. Has received full Annex 1 re-registration in the EU, although not registered in the USA. | | | | | |

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| **Pirimiphos-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Actellic) | None | | |
| **Application** | **Timing:** | Foliar, Post-harvest treatment, Fumigant | **Rate – (g/ha):** 500-2100 |
| **Crops** | **Main Pests** | | |
| F&V, Pome fruit | Wheat bulb fly and range of Insects and Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum insecticide/miticide with a wide range of crop and non-crop applications, mainly on stored grains and also in animal housing. Accepted for re-registration in the USA and EU. Authorisations of hand held applications of the product were revoked in 2011. A longer lasting CS formulation for indoor residual spraying for use in malaria control programmes has been developed by Syngenta in conjunction with the Innovative Vector Control Consortium. | | | | | |

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| **Polyoxin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other-Antibiotic | <30 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kaken  (Polyoxin AL) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200 |
| **Crops** | **Main Pests** | | |
| Pome Fruit | *Alternaria*, Powdery mildew | | |
| F&V, Turf, Tobacco | Powdery mildew, Botrytis, *Alternaria* and a range of other diseases | | |
| **Main Mixture Partners :** cyazofamid | | | | | |
| **Recent History:**  Fermentation product of the soil-borne bacterium *Streptomyces caccaoi*, its anti-fungal action is through the inhibition of chitin production. Offers disease control in many fruit & vegetable crops, benefiting from relatively low cost, high efficacy and broad spectrum of activity. Marketed by several companies in Japan, including Hokko, Kumiai and Nihon Nohyaku. Ishihara gained registration for the product in a mixture with cyazofamid as Greenwork in Japan in 2011. Arysta gained a label expansion in California for use of polyoxin-D as Ph-D on grapes, adding to approvals for turf, ornamentals and other food crops. In 2012 Certis USA, under agreement from Kaken, launched a new polyoxin-D salt formulation in the USA under the names Tavano, for grapes and small fruits, and Oso, for citrus, cucurbits and fruiting and leafy vegetables. In 2016 polyoxin D zinc salt was approved for use on apples and grapes in New Zealand, branded as Esteem. Has not been re-registered in the EU. | | | | | |

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| **Pretilachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | 95 | 1984 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Rifit, Solnet, Sofit) | Bharat Rasayan, Meghmani | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 400-800 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds, Sedges | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Rice herbicide used in most major Asian markets. A component in a number of significant ‘one-shot’ mixture products, notably Hokuto, Gorbo and Sparkstar. Formulations for both direct sown and transplanted rice have been introduced. Not registered in the EU although Italy granted emergency approval in 2017 to Rift 500 (pretilachlor) for use on rice. | | | | | |

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| **Primisulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <10 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Beacon) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 15-30 |
| **Crops** | **Main Pests** | | |
| Cereals, Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Early sulfonylurea in the maize sector, which benefited from the move to post-emergence treatments. Quickly overtaken by subsequent product introductions, but still finds minor usage, especially in a number of mixture formulations. Not re-registered in the EU. | | | | | |

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| **Probenazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other Azoles | 50 | 1981 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Meiji Seika (Oryzemate) | FarmHannong, Hokko Chemical | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 2400-3200 |
| **Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| **Main Mixture Partners :** carbosulfan, fipronil, chlorantraniliprole | | | | | |
| **Recent History:**  One of the leading products for rice blast control in Japan. Owes its efficacy to plant activation. Probenazole predominantly controls blast on the leaves; if this is adequately controlled then disease spread to the head can be prevented. Sales have benefited from use with fipronil as Dr Oryzae Prince, an insecticide/blasticide product for nursery box application, systemic activity passing with the plant on transplantation, and more recently Dr Oryzae-Ferterra (probenazole and chlorantraniliprole) and Builder-Ferterra-Chess (probenazole, chlorantraniliprole and pymetrozine). In 2005 Meiji Seika outsourced production to the Chinese company Tianjin Xinwei. | | | | | |

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| **Prochloraz** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other azoles | 140 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF, FMC (Sportak) | Adama | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 300-500 |
| **Crops** | **Main Pests** | | |
| Cereals | Septoria leaf spot, Net blotch, Leaf blotch, Eyespot | | |
| F&V, Rice | A wide range of diseases | | |
| **Main Mixture Partners :** propiconazole, carbendazim, tebuconazole, fenbuconazole | | | | | |
| **Recent History:**  Fungicide that finds most of its use for the control of true eyespot (*Pseudocercosporella herpotrichoides*) and some control of sharp eyespot (*Rhizoctonia cerealis*) in cereals. Frequently used in mixtures to broaden the activity spectrum of other cereal fungicides. Originally one of the most important cereal fungicides, prochloraz has now lost market share to more recent products offering eyespot protection, with sales dependant on the level of disease pressure. Foliar usages in Europe and seed treatments worldwide were divested to BASF by Bayer following the acquisition of Aventis. Gained re-registration in the EU in 2012 with approval extended until the end of December 2021. FMC acquired the non-European rights to the product from Bayer in 2011. The product is not registered for use in the US. | | | | | |

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| **Procymidone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Dicarboxamide | 40 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Su Ke Ling, Sumisclex) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-1000 |
| **Crops** | **Main Pests** | | |
| F&V, Pome fruit, Potato | A wide range of diseases | | |
| Vine | *Botrytis* | | |
| **Main Mixture Partners :** thiophanate-methyl | | | | | |
| **Recent History:**  Offers systemic activity against *Sclerotinia*, *Monilia* and *Helminthosporium* spp. on a range of fruit and vegetable crops. At one time a leading product for *Botrytis* (grey mould) control on vines with preventative, curative, and residual activity. Has not been re-registered in the EU. | | | | | |

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| **Prodiamine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | <30 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Barricade) |  | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 375-2000 |
| **Crops** | **Main Pests** | | |
| Turf, Ornamentals, Rice | Annual grasses and broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Originally developed by Velsicol and became part of the Sandoz portfolio before passing on to Novartis and then Syngenta. Of limited commercial significance, but still finds sales on turf and in non-crop situations. Nufarm holds the US marketing rights to the product, where it is sold as Endurance. Syngenta received Australian approval for Barricade for use on turf in 2011. | | | | | |

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| **Profenophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 85 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Curacron) | Chinese Companies, Excel Crop Care, Coromandel, Punjab Chemicals, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 125-750 |
| **Crops** | **Main Pests** | | |
| Cotton | Bollworm complex, Other Lepidoptera, White fly, Aphid, Mites | | |
| Soybean | Lepidoptera | | |
| Plantation crops, F&V | A wide range of insects and mites | | |
| **Main Mixture Partners :** lufenuron | | | | | |
| **Recent History:**  Non-systemic organophosphate insecticide particularly active on caterpillars and one of the most active products in its class for mite control. The product has become one of the cornerstones of the Syngenta insecticide portfolio, complementing products from other chemical classes. Main usage is on cotton, but also has registrations for use on a number of other crops, notably soybeans and fruit & vegetables. The product has attracted some regulatory scrutiny and has not been re-registered in the EU. | | | | | |

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| **Profluthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Fairytale) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Non-crop | Wool moths, Moth flies | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyrethroid ester insecticide commercialised in Japan in 2004 for use in non-crop situations, including against mosquitoes and cockroaches. | | | | | |

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| **Profoxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | <30 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Aura, Tetris) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100 – 150 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Formerly known as clefoxydim. First introduced in Latin America in 1999 as Aura, with registrations following in Spain, Portugal and East Asia as Tetris. Received registration in the EU in 2011 with approval extended until the end of July 2021. | | | | | |

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| **Prohexadione** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <30 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Viviful) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cereals, Pome fruit, Rice, F&V | None | | |
| **Main Mixture Partners :** mepiquat-chloride | | | | | |
| **Recent History:**  Plant growth regulator for lodging control in cereals and rice introduced by BASF as Apogee for use on apples in the USA. The product reduces vegetative growth allowing increased light penetration to improve fruit colouring. BASF also introduced the product in mixtures for use on cereals, including in France with mepiquat as Medax Top in 2003. Has achieved Annex 1 approval in the EU. Iharabras received Brazilian approval for the product in 2009 as Viviful for foliar application on apples, cotton, potatoes and ornamentals. In 2014 Nufarm launched Anuew, containing the prohexadione-calcium salt form of the molecule, for use on ornamental lawns, golf courses and athletic turf surfaces. | | | | | |

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| **Prometryn** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 40 | 1962 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Gesagard) | Oxon, Adama, Meghmani | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 700-2500 |
| **Crops** | **Main Pests** | | |
| Cotton, Rice, F&V, Sunflower, Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** metolachlor | | | | | |
| **Recent History:**  Commodity triazine herbicide for annual grass and broadleaved weed control. The product is also used in a number of mixture formulations, primarily in sunflowers. Has not been re-registered in the EU. A generic form was introduced by Adama in the USA in 2004 as Vegetable Pro. In 2010 Adama’s Cotton Pro and Vegetable Pro were added to Monsanto’s Roundup Ready Plus platform in the USA. | | | | | |

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| **Propachlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | <10 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Ramrod) | Adama, Nitrokemia, TRI Chemical | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 2900-6700 |
| **Crops** | **Main Pests** | | |
| F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity chloroacetanilide pre-emergence herbicide for use on vegetables. Now a product of minor commercial significance and has not been re-registered in the EU. | | | | | |

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| **Propamocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Carbamate | 90 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Previcur N) | None | | |
| **Application** | **Timing:** | Seed treatment, Soil applied | **Rate – (g/ha):** 1100-110000 |
| **Crops** | **Main Pests** | | |
| Potato | Potato blight | | |
| F&V, Oil palm | A wide range of diseases | | |
| **Main Mixture Partners :** mancozeb, chlorothalonil, fenamidone, fluopicolide, cymoxanil | | | | | |
| **Recent History:**  Preventative fungicide used mostly on ornamentals and vegetables as a seed treatment or soil application, particularly for the control of *Pythium* and *Phytophthora* diseases. An ageing product in a very competitive market sector, with sales also having been impacted by resistance development. Has received approval in Canada, and achieved re-registration in the EU, with this being extended until 2018. Infinito, a combination with fluopicolide for use on potatoes, was introduced in 2007 in Poland, Germany and Austria, followed by Belgium and Chile in 2008, Brazil in 2009, Peru in 2010 and Colombia in 2012. In 2012 Belchim launched Axidor, a combination with cymoxanil, in Italy for use in the horticulture sector. Bayer launched Consento, a mixture also containing fenamidone, in Italy to control late blight on tomatoes during 2016. Also in 2016, Arysta launched Proplant in Brazil to control late blight of potatoes. | | | | | |

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| **Propanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 75 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Surcopur) | Proficol, Adama, Chemia, Cedar, Nufarm, Agro-San, Agro-Islena, Bharat Rasayan, Meghmani, UPL | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 2500-6000 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity contact herbicide for grass and broadleaved weed control in rice. Remains one of the leading products for rice in the USA. Has been refused re-registration in the EU. Dow dropped the cereal use label in the USA in 2002. UPL acquired Dow’s global propanil herbicide business in 2006. | | | | | |

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| **Propaquizafop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 45 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Agil) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 70-280 |
| **Crops** | **Main Pests** | | |
| Rape, F&V, Soybean, Sugarbeet | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  One of the most active graminicides, although not marketed in the USA. The product has been introduced on most broadleaf crops in Europe. Adama acquired the product from Novartis on the formation of Syngenta. Has achieved re-registration in the EU with approval extended until the end of November 20121. | | | | | |

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| **Propargite** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 60 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Omite) | Chinese Companies, UPL | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 825-7300 |
| **Crops** | **Main Pests** | | |
| F&V, Maize, Pome fruit, Cotton | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  For some time the leading specific miticide on the global market, although the product is now subject to generic competition and regulatory action. Benefits from the absence of any significant build-up of resistance, however some labels have been lost with sales now in a phase of decline. Has not been re-registered in the EU, leaving that market in 2012. Now part of Arysta following Platform’s acquisition of Chemtura. In 2013 Arysta launched the acaricide Pallid-X in India. | | | | | |

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| **Propiconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 295 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Tilt) | Dow, Tagros, Adama, Meghmani, Atul, Chinese companies | | |
| **Application** | **Timing:** | Seed treatment, Foliar | **Rate – (g/ha):** 70-125 |
| **Crops** | **Main Pests** | | |
| Cereals | Brown rust, Leaf blotch, Net blotch, Septoria leaf spot | | |
| Rice | Sheath blight, Stem Rot | | |
| F&V, Plantation crops, Maize, Soybean | A wide range of diseases | | |
| **Main Mixture Partners :**  difenoconazole, trifloxystrobin, fenpropidin, tebuconazole, picoxystrobin, cyproconazole, carbendazim, prochloraz, cyprodinil, fenpropimorph, azoxystrobin, trifloxystrobin, benzovindiflupyr | | | | | |
| **Recent History:**  At one time the leading fungicide in the cereal sector, although now superseded by more recent introductions. Still an important part of the Syngenta portfolio, providing the triazole element in many cereal fungicide mixtures, notably with the strobilurins. Re-registered in the EU until the end of January 2018. The brands Tilt and Stereo (cyprodinil and propiconazole) are marketed by Adama in the Nordic countries. In 2013 Adama received US approval for an emulsifiable concentrate formulation for use on maize, soybeans and sorghum. Recent combination product introductions with azoxystrobin include Syngenta’s Quilt Excel in the US for use on barley, triticale and wheat; and Adama’s Topnotch for use on cereals in Canada. In 2014 Arysta LifeScience introduced Astera Fungicide with αβpro Yield Enhancer, a combination with Plant Health Care's harpin technology, for use on maize. In 2016 Syngenta launched Trivapro (azoxystrobin, propiconazole and benzovindiflupyr) in Canada for use on maize, soybeans and cereals. | | | | | |

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| **Propineb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite -Dithiocarbamate | 70 | 1967 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Antracol) | Dhanuka | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 1000-2000 |
| **Crops** | **Main Pests** | | |
| Vine | Downy mildew, Excoriosis | | |
| F&V, Plantation crops, Pome fruit, Rice | A wide range of diseases | | |
| Potato | Early blight, Potato blight | | |
| **Main Mixture Partners :** iprovalicarb, triadimenol, cymoxanil, triadimefon, copper-oxychloride, fluopicolide | | | | | |
| **Recent History:**  Polymeric contact dithiocarbamate fungicide mainly used for downy mildew control on vines, scab on pome fruit and early and late blight on potatoes, as well as other *Alternaria* and *Phytophthora* diseases on fruit and vegetables. In 2011 Bayer launched the product in a mixture with fluopicolide as Trivia in Peru. Has been re-registered in the EU until the end of January 2018, although Bayer’s application for registration of the product in the USA was withdrawn in 2013. Dhanuka introduced the active ingredient as Protocol in 2014. | | | | | |

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| **Propisochlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | <30 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Proponit) | Chinese companies. | | |
| **Application** | **Timing:** | Pre-plant, Pre-emergence | **Rate – (g/ha):** 1440-2160 |
| **Crops** | **Main Pests** | | |
| Sunflower, Maize | Grasses and Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Persistent chloroacetanilide pre-emergence herbicide offering control of newly emerging weeds. First introduced by Nitrokemia and acquired by Arysta in 2006, with registration taking place in Hungary, Bulgaria, Croatia, Poland, Armenia, Romania, Slovakia, and other countries in Asia and South America. Arysta has since introduced the product in Mexico, Chile, Ukraine and Russia. Not accepted for re-registration in the EU. | | | | | |

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| **Propoxycarbazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS | 35 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer  (Attribut, Olympus) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 30-70 |
| **Crops** | **Main Pests** | | |
| Cereals | Grass weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Triazolinone herbicide for use on wheat, winter rye, and triticale. Primarily used to control of black grass, loose silky bent, brome grasses, and couch in continual cereal production areas. The strength of the product is the control of the rhyzomatous grass couch during the growing season, the normal treatment for this being pre-emergence glyphosate. Has achieved re-registration in the EU. Introduced in East Europe in 2001 and most primary European markets in 2002, followed by France in 2003 and the USA in 2004. Wilbur-Ellis market and distribute the product as Canter R&P for the range, pasture and CRP markets in the USA. | | | | | |

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| **Propyrisulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Sulfonylurea | <30 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Zeta-One and MegaZeta) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Barnyard grass, Water chestnut, Arrowhead | | |
| **Main Mixture Partners :** bromobutide, benzobicyclon, pyraclonil, pyrazolate | | | | | |
| **Recent History:**  Originally developed by Takeda and inherited by Sumitomo. A selective broad-spectrum herbicide with some residual activity, exhibiting high efficacy against sulfonylurea-resistant weeds. Registered in Japan in 2008, with first sales commencing in 2009. In 2011 Sumitomo launched the product in Japan in granulated, flowable and ‘jumbo’ formulations. This was followed in 2013 in South Korea in suspension concentrate and jumbo formulations. Sumitomo Chemical has received approval for the product in Vietnam as Zeta-One. Has not been approved for use in the EU. | | | | | |

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| **Propyzamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 90 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Kerb) | Chinese Companies | | |
| **Application** | **Timing:** | Pre-emergence,  Post-emergence | **Rate – (g/ha):** 300-4500 |
| **Crops** | **Main Pests** | | |
| Rape, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** aminopyralid | | | | | |
| **Recent History:**  Residual amide herbicide predominantly used on fruit and vegetables in the USA and on oilseed rape in Europe. Became part of the Dow portfolio on the acquisition of Rohm & Haas. Offers an alternative mode of action for grass weed control on rape to the ‘fops’ and ‘dims’, therefore useful where resistance development has become a problem. Achieved re-registration in the EU, with approval extended to the end of January 2018. In 2009 Irish company AgriGuard received UK approval as Solitaire and Setanta, reportedly the first generic registrations for the product in the EU. In 2013 Dow launched AstroKerb (propyzamide and aminopyralid) for use on oilseed rape in the UK. | | | | | |

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| **Proquinazid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Talius, Talendo) |  | | |
| **Application** | **Timing:** | **Foliar** | **Rate – (g/ha):** 50-75 |
| **Crops** | **Main Pests** | | |
| Cereals, Vine | Powdery mildew | | |
| **Main Mixture Partners :** prochloraz, tebuconazole | | | | | |
| **Recent History:**  Quinazolinone fungicide specifically for the control of powdery mildew. Introduced in Poland, Hungary, Austria and Ireland in 2005.  Registered for use on cereals in the UK, Germany and the Czech Republic in 2006 and approved in France and Italy for use on vines in 2007. Has received approval in the EU with approval extending until the end of July 2020. Gained approval as Talendo in Australia in 2012 for use on grapevines. | | | | | |

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| **Prosulfocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | 115 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Boxer, Defy) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 3000-4000 |
| **Crops** | **Main Pests** | | |
| Cereals, Potato | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum thiocarbamate herbicide for use on cereals that offers control of *Gallium*, hence its major market is in Europe. Also offers control of other grass and broadleaf weeds, with recent sales benefiting from usage in the control of weeds which have developed resistance to other chemistries. Australian approval was granted in 2006, with this now the main country market for the product. Re-registration in the EU has been achieved with approval extended until the end of October 2018. | | | | | |

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| **Prosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Peak, Casper) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 10-30 |
| **Crops** | **Main Pests** | | |
| Maize, Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** bromoxynil, primisulfuron | | | | | |
| **Recent History:**  Sulfonylurea herbicide for post-emergence broadleaf weed control in maize that has been introduced in most major maize markets, mainly in mixtures with other products, primarily primisulfuron. In addition to maize the product has also been introduced for use on cereals, including in the UK in 2004. The product gained approval as Casper in Australia in 2012 for use on turf. In 2017 the EU imposed new maximum application rate of one application every three years on the same field at a maximum rate of 20g ai/ha. | | | | | |

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| **Prothioconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI-Other azole | 790 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Proline, Input, Prosaro) | None | | |
| **Application** | **Timing:** | Foliar, Seed applied | **Rate – (g/ha):** 200 |
| **Crops** | **Main Pests** | | |
| Cereals | Septoria leaf spot, Eyespot, sharp Eyespot, *Fusarium*, *Rhyncosporium*, Yellow and Brown rust, Powdery mildew, Net Blotch, Leaf Blotch | | |
| Soybean | Asian rust, Frogeye leaf spot | | |
| Rape | Light and Phoma leaf spot, Sclerotinia stem rot | | |
| **Main Mixture Partners :** spiroxamine, trifloxystrobin, fluoxastrobin, tebuconazole, penflufen, metalaxyl, bixafen, clothianidin | | | | | |
| **Recent History:**  Highly active azole fungicide with a broad spectrum of activity. Has received excellent market acceptance since introduction, leading to rapid sales growth in both the foliar and seed treatment markets. Recent sales growth has been driven by usage in Brazil for the control of Asian rust. Has received EU Annex 1 approval with approval extending until the end of July 2018. Widely used in a number of combination products, including with trifloxystrobin as Fox in Brazil and Stratego YLD in the USA; with fluoxastrobin and tebuconazole as Scenic in Argentina and Chile; with trifloxystrobin in Turkey for use on wheat; with bixafen as Aviator Xpro in the UK Germany and Chile; with fluopyram as Propulse in the USA for beans and sugarbeet; with clothianidin and penflufen as Titan Ernesto in Canada for potato seed piece treatment; with tebuconazole and metalaxyl as Raxil Pro Shield for use on cereals in Canada; and with tebuconazole as Redigo Pro in the UK. DuPont Pioneer has an agreement for Evergol Energy (with penflufen and metalaxyl) to be used as a seed treatment for soybeans. In 2017 Bayer launched Aviator Xpro, a mixture with bixafen, for use on canola and chickpeas in Australia. | | | | | |

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| **Prothiofos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <30 | 1978 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Tokuthion) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 600-2000 |
| **Crops** | **Main Pests** | | |
| F&V, Plantation crops, Rice | Insects, Aphids, Armyworm, Caterpillars, Cutworms, Thrips | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorous insecticide for the control of leaf eating caterpillars, mealy bugs and scale insects. Also finds some sales in the public health sector for the control of flies and mosquitoes. Not re-registered in the EU or USA. Approval in New Zealand is due to end on 30th of June 2023. The product was acquired by Arysta from Bayer in 2005. | | | | | |

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| **Pydiflumetofen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | <10 | 2016 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Adepidyn, Miravis) |  | | |
| **Application** | Timing: | Foliar | **Rate– (g/ha):** 30-200 |
| **Crops** | **Main Pests** | | |
| Vegetables, Specialty Crops, Maize, Soybean, Cereals, Diverse Field Crops | Fusarium Head Blight, leaf spots, powdery mildews and moulds. | | |
| **Recent History:**  Entered launch phase in 2016 with registration initially in Argentina under the brand name Adepidyn. In early 2017 this was followed by the launch of Miravis Duo (pydiflumetofen and difenoconazole) in Argentina for use on soybeans against end of cycle diseases. Also being positioned in Uruguay for the control of late season disease complex. Currently under registration review in the USA with a decision scheduled for late in November 2017. | | | | | |

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| **Pyflubumide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide (Pyrazole) | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Danikong, Doubleface) | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Grape vines, Tea, Ornimentals | Mites | | |
| **Recent History:**  Developed as NNI-0711. Gained approval in 2015 for use in Japan. | | | | | |

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| **Pymetrozine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | 105 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Chess, Plenum, Fulfill) | Chinese Companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-50 |
| **Crops** | **Main Pests** | | |
| F&V, Tobacco | A range of insects | | |
| Rice | Whiteback planthopper, Brown planthopper, Green leafhopper, Stink bug | | |
| Potato | Aphids | | |
| **Main Mixture Partners :** chlorantranilipole | | | | | |
| **Recent History:**  Low application rate specific aphicide with activity against juvenile stages of whitefly, offering a novel mode of action. The product has been well received in East Asia and has also been introduced in Europe, the USA and Mexico. Has achieved Annex 1 approval in the EU until the end of June 2018. Syngenta has introduced the product for use on oilseed rape in France, Germany, Hungary and Poland. In 2017 Adama took over Syngenta’s Fulfill product in the US. | | | | | |

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| **Pyraclofos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1989 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Voltage) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 250-1500 |
| **Crops** | **Main Pests** | | |
| F&V | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorous insecticide active against Lepidoptera*,* Coleoptera, mites, and nematodes, mainly used on fruit and vegetables. Now of limited commercial significance but continues to find usage in public health markets. Not re-registered in the EU. | | | | | |

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| **Pyraclonil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | 80 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kyoyu Agri | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, broadleaf weeds and sedges | | |
| **Main Mixture Partners:** flucetosulfuron, mesotrione, imazosulfuron, bromobutide, propyrisulfuron | | | | | |
| **Recent History:**  PPO herbicide first registered in Japan in 2007, with commercial launch taking place in 2009. Has been well accepted since introduction, benefiting from use for the control of sulfonylurea resistant weeds. Now the leading rice herbicide active ingredient in the Japanese market, being widely used in mixtures with other products in the one-shot rice herbicide market. In 2017 Nihon Noyhyaku’s US subsidiary, [Nichino America](https://www.agra-net.com/agra/agrow/companies-business/deals/nichino-americakyoyu-agri-agree-us-deal-on-pyraclonil--1.htm), agreed a licensing deal with Japanese company Kyoyu Agri for pyraclonil. Additionally, the a.i. was approved in China in 2016. | | | | | |

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| **Pyraclostrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 765 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Cabrio, Headline, Opera) | None | | |
| **Application** | **Timing:** | Foliar, Seed applied | **Rate – (g/ha):** 50-560 |
| **Crops** | **Main Pests** | | |
| Soybean | Asian Rust, Leaf spot, Aerial Blight, Leaf blight, Frogeye leaf spot, Pod and Stem blight, Leaf and Stem spot, Target spot | | |
| Cereals | Brown rust, Yellow rust, Septoria leaf spot, Leaf blotch, Powdery mildew | | |
| Maize, F&V, Vine | A wide range of diseases | | |
| **Main Mixture Partners :**  epoxiconazole, kresoxim-methyl, folpet, tebuconazole, boscalid, fenpropimorph, boscalid, fluxapyroxad, thiophanate-methyl, bifenthrin | | | | | |
| **Recent History:**  One of the most active strobilurins with broad-spectrum activity for foliar and seed treatment use. A component in a number of combination products, including with fluxapyroxad and epoxiconazole in Argentina as Orquestra Ultran for soybeans; with fluxapyroxad as Priaxor in the USA and Canada in 2012, and Argentina in 2013 and as Orkestra in Brazil in 2014; and with fluxapyroxad as Lexicon Intrinsic for use on turf in the USA. BASF supply Monsanto with pyraclostrobin for use in Monsanto’s Acceleron seed treatment system. Seed treatment supply agreements have also been reached with Incotec, for brassica seed in the USA, and with Sursem for soybean seed in Argentina for Acronis (with thiophanate-methyl). During 2015 BASF gained approval for Seltima (pyraclostrobin utilising the company’s encapsulation technology) in Indonesia for use on rice, and Obvius (metalaxyl, fluxapyroxad and pyraclostrobin) in the USA for pulses, podded vegetables and canola. In 2016 BASF’s Signum, a mixture also containing boscalid, gained a usage extension in Canada for application on broccoli, cabbage and cauliflower in France. Also in 2016, BASF launched Ativum EC for use in Brazil to combat soybean rust. Has been re-registered in the EU. | | | | | |

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| **Pyraflufen-ethyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | <30 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Desal, Ecopart, Mogeton) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 10 – 20 |
| **Crops** | **Main Pests** | | |
| Cereals, Cotton, Pome fruit, F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** bifenox, ioxynil, 2,4-D | | | | | |
| **Recent History:**  Phenylpyrazole herbicide active via PPO inhibition with selective activity against *Galium aparine* (cleavers) and *Stellaria media* (chickweed). Rapid action led to non-crop usage with sulfosate as Thunderbolt. Introduced in Japan and later developed for other markets. Registered in the EU where it is marketed by Adama in a mixture with bifenox as Milan, whilst Bayer sells the product in France in a combination with bifenox and ioxynil. EU approval was extended during 2016 until the end of March 2031. Gowan have launched the product as Vida in the USA for use in burndown, post-emerge corn, soybeans, wheat and as a potato desiccant. Certis Europe has been appointed as distributor of Quickdown in the Netherlands, Belgium and Luxembourg. In 2010 Nufarm was appointed distributor for Edict for non-crop uses in the USA. Certis launched the product as Piramax in Italy in 2012. In 2014 Nufarm gained approval for product for use on maize, wheat and soybeans in Canada. In 2016 Nufarm launched Blackhawk in Canada, a mixture with 2,4-D for use on cereals. | | | | | |

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| **Pyraoxystrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | <10 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Shenyang Research Institute |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Cereals | Broad spectrum, including oomycete diseases and botrytis. | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Broad spectrum fungicide for use against downy mildew, powdery mildew, grey mould, rice brown spot and early blight. Received registration in China in 2009. | | | | | |

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| **Pyrasulfotole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | 65 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Huskie) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 25-50 |
| **Crops** | **Main Pests** | | |
| Cereals | Broadleaf weeds (notably *Stellaria, Chenopodium, Solanum, Amaranthus* and *Abutilon*) | | |
| **Main Mixture Partners :** MCPA, bromoxynil, fenoxaprop-P-ethyl, thiencarbazone-methyl, bromoxynil, fluroxypyr | | | | | |
| **Recent History:**  Herbicide with a novel mode of action in cereals, inhibiting enzymes critical for plant pigment formation, used in combination with a safener. Also developed for use in a resistance management program to control sulfonylurea-resistant weeds. The first HPPD inhibitor for cereals to be used in North America, introduced in the USA in 2008. Not currently registered in the EU. Registered in Australia in 2008 as Precept, a mixture with MCPA. Canadian approval was granted for Infinity (pyrasulfotole and bromoxynil) in 2008. Huskie is a mixture formulation also incorporating bromoxynil and the safener mefenpyr. Wolverine, a combination of pyrasulfotole with bromoxynil, fenoxaprop-P-ethyl and mefenpyr, was approved in the USA and Canada in 2009 for use on wheat and barley. Launched as Velocity in Australia in 2009. Tundra, a combination with fenoxaprop P-ethyl and bromoxynil, was introduced in Canada in 2010. Huskie Complete, a mixture with thiencarbazone-methyl, received US approval for use in wheat in 2012. In 2016 Bayer introduced Infinity FX (with bromoxynil and fluroxypyr) in Canada. | | | | | |

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| **Pyrazolynate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <30 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Sanbird) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 3000 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses and Sedges | | |
| **Main Mixture Partners :** butachlor, pyrazolynate | | | | | |
| **Recent History:**  Pyrazole herbicide for grass and sedge control that is used mainly in ‘one-shot’ products, as Kusakarin (pyrazolynate and butachlor) and in the Jumbo formulation Slasher (1999). | | | | | |

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| **Pyrazosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 35 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Sirius) | UPL, Chinese Companies | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 10-50 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, broadleaved weeds | | |
| **Main Mixture Partners :**  molinate, mefenacet, pyriminobac-methyl, esprocarb, pretilachlor, dimethametryn, cyhalofop, cafenstrole, penoxsulam, oxaziclomefone, pyraclonil, benzobicyclon | | | | | |
| **Recent History:**  Sulfonylurea herbicide predominantly used as an element in many ‘one-shot’ rice herbicides to provide the broadleaf weed and sedge control, most notably initially in Hokuto (with cyhalofop, pretilachlor and dimethametryn), Boss (with indanofan and benzobicyclon), and W-Star (with fentrazamide). Retains a steady share of the Japanese ’one-shot’ herbicide market and is also sold in South Korea, Vietnam, India and China. Nissan received Japanese approval for the product in a mixture with penoxsulam, oxaziclomefone and benzobicyclon as SiriusDash and with oxaziclomefone and benzobicyclon as SiriusTarbo in 2010, and with oxaziclomefone, pyraclonil and benzobicyclon as Sirius Exa in 2011. UPL launched the product as Saathi in India in 2013 for use on paddy rice. | | | | | |

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| **Pyrazoxyfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <10 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Paicer) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 2500-4000 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :**  cafenstrole, daimuron, benzobicyclon, azimsulfuron | | | | | |
| **Recent History:**  Pyrazole rice herbicide used to provide the grass weed control element in ‘one-shot’ products. Initially introduced in One-all (a mixture with pretilachlor) now superseded by more recent products and of limited commercial significance. Pyrazoxyfen-based products are also sold in Korea and Taiwan. In 2011 Ishihara gained Japanese registration for the product in the Tobikiri range in a mixture with cafenstrole, daimuron and benzobicyclon; with benzobicyclon as Prekeep; and with azimsulfuron, cafenstrole and benzobicyclon as Broad-cut. | | | | | |



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| **Pyribencarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Fantasista) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Fruit, Vegetables, Tea | *Botrytis cinerea*, *Sclerotinia sclerotiorum*, several diseases | | |
| **Main Mixture Partners :**  iminoctadine trialbesilate | | | | | |
| **Recent History:**  Benzylcarbamate fungicidedeveloped as KIF-7767 that acts at the quinone ‘outer’ binding site of the cytochrome bc1 complex, similar to the strobilurins. Kumiai also market the combination product Fanbel (pyribencarb and iminoctadine trialbesilate). | | | | | |

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| **Pyribenzoxim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Other | <10 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| LG Chemical (Pyanchor, Kiljabi Gold) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 20-50 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Post-emergence grass and broadleaf weed herbicide for use on rice, the first proprietary product to be introduced by LG Chemical. Introduced in Korea in 1997, followed by China (2000) and Vietnam (2001). In 1999 an agreement was reached for Rohm & Haas, now Dow, to market the product on a worldwide basis. Introduction has also been achieved in several other countries in Asia and Latin America. | | | | | |

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| **Pyributicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <10 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tosoh (Toyocarb) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 1000-1350 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** pretilachlor, dimethametryn | | | | | |
| **Recent History:**  Thiocarbamate herbicide active against annual grass weeds, used in premixes with other herbicides for one-shot products such as Karshot, Award and Seezet. | | | | | |

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| **Pyridaben** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 45 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Sanmite, Pyramite, Nexter) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 1500-6000 |
| **Crops** | **Main Pests** | | |
| Plantation crops, Cereals, Pome fruit, F&V, Vine | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyridazinone miticide/insecticide with a rapid knockdown activity. Licensed to BASF for marketing in Europe (Nexter) and the USA (Pyramite) for use on vines and fruit crops. Gowan began marketing Nexter in the USA in 2007 after gaining the North American rights from Nissan in the previous year. At one time the leading miticide in Japan but now suffering from resistance development. Re-registered in the EU with approval extended until the end of April 2021. Introduced in further fruit crops in the USA and Canada, where it is marketed by Gowan. | | | | | |

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| **Pyridalyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | <10 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Pleo) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Ornamentals | Lepidoptera, Thrips, Leafminers | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Highly active against the larvae of lepidopteran pests, including strains resistant to other insecticides. Launched in Japan, Korea, and Thailand in 2004, followed by Australia and India in 2005. Approved in China in 2007 for use on cabbages. Sumitomo’s US subsidiary Valent received US approval in 2008 for use on glasshouse-grown vegetables and ornamentals. Has gained full registration in the EU with approval extending until the end of June 2024. | | | | | |

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| **Pyridaphenthion** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Ofunack) | Sipcam | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 100-1000 |
| **Crops** | **Main Pests** | | |
| F&V | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Organophosphorous insecticide active against rice pests including stem borers, green rice hoppers and plant hoppers, the first product from Mitsui Chemicals’ own research program. Now a mature product with declining sales and not registered in the EU or the US. | | | | | |

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| **Pyridate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other - Pyridazine | <10 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Belchim (Lentagran) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 1000-1500 |
| **Crops** | **Main Pests** | | |
| F&V | Broadleaved weeds | | |
| **Main Mixture Partners :** terbuthylazine, bromoxynil | | | | | |
| **Recent History:**  Pyridazine broadleaf weed herbicide with a wide application window, purchased by Sandoz from Agrolinz in 1995. Positioned as an atrazine replacement and at one time an important product in the maize herbicide market. Has achieved Annex 1 listing in the EU. The US EPA cancelled all uses in 2007 at Syngenta’s request, with sales now achieved mainly in Europe where Belchim (since 2006) has the exclusive license on vegetable crops in all EU countries. Further registrations were subsequently achieved, notably in the UK in 2008. Belchim launched Lentagran in Italy in 2012. | | | | | |

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| **Pyrifenox** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other | <10 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Dorado) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 40-140 |
| **Crops** | **Main Pests** | | |
| Vine | Powdery mildew | | |
| Pome fruit, Stone fruit | A wide range of diseases | | |
| **Main Mixture Partners :** captan | | | | | |
| **Recent History:**  Pyridine fungicide with systemic activity against powdery mildew and *Monilia*. The primary target is powdery mildew on vines and apples (also effective against scab on apples). Other main use is on fruit trees, particularly apricots, peaches and plums. Also marketed in a mixture with captan as Rondo. Not re-registered in the EU and left that market in July 2003. | | | | | |

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| **Pyrifluquinazon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other (Quinazolinone) | <10 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Colt) |  | | |
| **Application** | **Timing**: |  | **Rate – (g/ha):** 12.5-125 |
| **Crops** | **Main Pests** | | |
| F&V | Hemiptera (aphids, whitefly and scales) | | |
| **Recent History:**  Jointly developed with Kumiai Chemical. Active against hemipteran pests, particularly aphids, whiteflies and scales. Acts as an insect behaviour regulator, causing rapid cessation in insect sucking, with pests eventually starving to death. Well suited for use in Integrated Pest Management and Insecticide Resistance Management programmes. Registered in Japan in 2010 for use on horticultural crops. The product has also been developed as a 20% water-dispersible granule formulation for use on vegetables, fruit and tea. Has also been introduced in South Korea. | | | | | |

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| **Pyriftalid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS Other | <30 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta  (Apiro-Ace) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 180 |
| **Crops** | **Main Pests** | | |
| Rice | Grass weeds | | |
| **Main Mixture Partners :** cinosulfuron, azimsulfuron, mesotrione, bensulfuron, metazosulfuron, pretilachlor | | | | | |
| **Recent History:**  Used in a number of granular mixture formulations, including ‘one-shot’ products. Approved in South Korea in 2001 with commercial introduction in a mixture with cinosulfuron as Apiro-Ace in 2002. Further introductions have been achieved in several other major rice markets, including Japan in 2003. In 2014 Mitsui Chemicals launched the late rescue treatment Oshioki MX, a mixture with azimsulfuron and mesotrione, in Japan. | | | | | |

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| **Pyrimethanil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Anilinopyrimidine | 52 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Scala) | Bayer | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| F&V, Pome fruit | Grey mould, Leaf Scab | | |
| Vine | *Botrytis* | | |
| **Main Mixture Partners :** chlorothalonil, fluquinconazole, trifloxystrobin, fluopyram | | | | | |
| **Recent History:**  Anilinopyrimidine fungicide with protective activity against *Botrytis* and curative action against *Venturia*. Main usage is on vines in Europe for *Botrytis* control and against leaf scab on pome fruit. Accepted for re-registration in the EU. Foliar usage in Europe and worldwide seed treatment usage was divested by Bayer to BASF following the acquisition of Aventis. Introduced by Bayer in the USA in 2005 in a number of fruit & vegetable crops. Janssen have developed the compound for post-harvest usage on citrus and pome fruit. In 2012 Bayer launched the product in a mixture with fluopyram as Luna Tranquillity for use on various fruits, nuts and vegetables in the USA, and for use on apples and vines in Canada. Luna Tranquility was also introduced in Colombia in 2015 and Chile in 2017. In 2017 BASF unveiled Vision Plus (pyrimethanil, diathinon) in Spain for the control of scab in pome fruit. | | | | | |

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| **Pyrimidifen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <10 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Miteclean) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-75 |
| **Crops** | **Main Pests** | | |
| Plantation crops, F&V, Pome fruit | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Active against all stages of spider mites on a range of fruit and vegetable crops, and against diamond back moth on cabbage. The product has been registered in Taiwan and some East European markets and is also being developed for use on cotton. Also marketed by SDS Biotech in Japan. | | | | | |

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| **Pyriminobac-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Others | <30 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Prosper, Hieclean) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 30-90 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses | | |
| **Main Mixture Partners :** pyrazosulfuron-ethyl, pretilachlor, mefenacet, bromobutide, bensulfuron, pentoxazone | | | | | |
| **Recent History:**  ALS herbicide for the control of grass weeds, including barnyard grass in rice from pre-emergence up to the 4-leaf stage. The product can be used in dry-seeded, water-seeded and transplanted rice at any growth stage. Main use is in one-shot mixtures, especially Prosper (with pretilachlor and mefenacet). A lower application rate formulation, Topgun, was launched in Japan in 2005, with a new formulation launched in 2011. | | | | | |

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| **Pyrimisulfan** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS - Sulfonanilide | <30 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Atotori, Bestpartner) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Grass weeds | | |
| **Main Mixture Partners:**  oxaziclomefone, benzobicyclon, fenoxasulfone, pyraclonil, pyrimisulfan, fentrazamide | | | | | |
| **Recent History:**  First registered in Japan in 2008, the product has since been introduced in a number of mixture formulations, including Naginata Jumbo and Naginata Mametsubu, both with oxaziclomefone and benzobicyclon; Zantetsu Mametsubu 250, also containing oxaziclomefone; and Zantetsu Jumbo, with benzobicyclon. More recently, Kumiai launched Gangan (fenoxasulfone and pyrimisulfan), Yabusame Mametsubu 250 (fenoxasulfone, pyraclonil and pyrimisulfan) and Benkei (fenoxasulfone, pyrimisulfan and benzobicyclon) in Japan in 2015. Iharabras has submitted the product for registration in Brazil. In 2017 the US company, [PBI-Gordon](https://www.agra-net.com/agra/agrow/companies-business/pbi-gordonkumiai-in-herbicide-deal--1.htm), entered into an exclusive partnership with Kumiai Chemical and its sister company, Ihara Chemical, to introduce pyrimisulfan, to the US turf market. | | | | | |

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| **Pyriofenone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 2011 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Property, Kusabi) |  | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** 50-100 |
| **Crops** | **Main Pests** | | |
| Vine, F&V | Powdery mildew | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  New class of fungicide based on benzoyl pyridine chemistry, developed as IKF 309, offering protective and curative control of powdery mildew. The mode of action is proposed as being via the disruption of actin. Gained approval in South Korea and the UK in 2012, and in Japan in 2013, where it is sold as Property. Received EU approval in 2014. In 2017 ISK launched Prolivo 300SC (pyriofenone) in the US for use on a range of fruit. | | | | | |

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| **Pyriprole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other - Pyrazole | <10 | 2016 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Nexus) | None | | |
| **Application** | **Timing:** | Soil, Foliar | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Hemipteran, Lepidopteran and Coleopteran pests, including aphids, fleas, bean weevils, brown rice planthopper, diamondback moth, cutworm and grasshoppers. | | |
| Non-Crop | Termites | | |  | |
| **Recent History:**  Active as an antagonist at GABA-gated Cl⁻ channels. Introduced by Novartis Animal Health for use in the animal health area worldwide as Prac-tic, following approval in 2007 in EU for use as a topical flea and tick spot treatment for dogs. After acquisition of AgriMart Corporation from Arysta during 2014, in 2016 Nihon Nohyaku launched a termite control product based on the a.i. as Nexus in Japan. | | | | | |

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| **Pyriproxyfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other IGR | 95 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Admiral, Knack, Tiger, Esteem) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-100 |
| **Crops** | **Main Pests** | | |
| F&V, Soybean, Cotton | A wide range of Insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Alkoxypyridine juvenile hormone mimic used to control whitefly and scale insects in fruit, vegetables, cotton and ornamentals. Also marketed for public health control of cockroaches and for use in animal health, with several flea treatments marketed by Summit VetPharm. Introduced for crop usage in the USA by Valent and for non-crop markets by Syngenta. Re-registration in the EU has been achieved until the end of 2018, with the current approval valid until the end of 2018. Nufarm formulate and package the product in Australia, with Sumitomo’s Australian subsidiary responsible for all distribution in the country. Nufarm markets the product in Romania, Hungary and Ukraine. | | | | | |

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| **Pyrithiobac** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Others | 35 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Staple) | DuPont | | |
| **Application** | **Timing:** | Pre-emergence,  Early post-emergence | **Rate – (g/ha):** 70 |
| **Crops** | **Main Pests** | | |
| Cotton | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Dimethoxypyrimidinyl-thiobenzoate herbicide, an analogue of pyriminobac-methyl, used for the control of broadleaved weeds in cotton. Co-developed and marketed by DuPont in the USA, with the product initially making a significant impact on the US cotton sector; however sales have since been affected by the uptake of herbicide tolerant varieties. The product is also marketed in Australia and Latin America. Adama’s pyrithiobac-sodium has been included in Monsanto’s Roundup Ready Plus program in the USA. | | | | | |

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| **Pyroquilon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Quinoline | <30 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Coratop) | None | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 300-2000 |
| **Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| **Main Mixture Partners :** thiamethoxam, chlorantraniliprole | | | | | |
| **Recent History:**  Protective rice blast fungicide also used as a systemic seed treatment, finding activity through the inhibition of melanin synthesis. Not re-registered in the EU and left that market from July 2003. | | | | | |

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| **Pyroxasulfone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Isoxazoline | 135 | 2011 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Sakura) |  | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 60-250 |
| **Crops** | **Main Pests** | | |
| Cereals, Soybean, Maize | Annual grass and some broadleaf weeds | | |
| **Main mixture partners:** fluthiacet-methyl, atrazine, flumioxazin, chlorimuron-ethyl | | | | | |
| **Recent History:**  Low application rate competitor to the acetanilides, first launched in Australia in 2011 as Sakura for use on wheat. BASF has since introduced the product in the USA as Zidua for use on maize, soybeans, wheat and cotton, and in non-crop situations. Kumiai received approval for the product in Canada for use on maize in 2012. FMC holds the exclusive development and marketing rights to premixes of pyroxasulfone with several of its herbicides in the USA, launching Anthem (pyroxasulfone and fluthiacet-methyl) and Anthem ATZ (Anthem and atrazine) in 2012. Other mixture products from FMC have been developed for use on vegetables, cotton, wheat and peanuts. Valent launched a combination with flumioxazin as Fierce for corn in the USA in 2012, with approval for soybeans received in 2013, following which Fierce was added to Monsanto’s Roundup Ready Plus soybean platform. In 2015 Kumiai introduced Soloist for use on turf in Japan. Launched by BASF in the USA as Zidua PRO (saflufenacil, imazethapyr, pyroxasulfone) for use on soybean in the 2017 season and in Canada for the 2018 season as Zidua SC (pyroxasulfone) for use on maize and soybean. | | | | | |

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| **Pyroxsulam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS – Other (Sulfonamide) | 210 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Simplicity, Admitt, Powerflex) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 9-18 |
| **Crops** | **Main Pests** | | |
| Cereals | Broad spectrum of grass and broadleaf weeds | | |
| **Main Mixture Partners :** pendimethalin, flupyrsulfuron | | | | | |
| **Recent History:**  Effective on hard to control grasses at very low rates with minimal crop rotation restrictions. The first registration for the product was achieved in Chile in 2007. Registered in 2008 by the US EPA as Powerflex for use on winter wheat, Australia as Crusader and in Canada as Simplicity. Approved in Turkey and the UK in 2009. Dow introduced Broadway Sunrise, a mixture with pendimethalin, in the UK for use on wheat in 2010, and Unite, a mixture with flupyrsulfuron for oilseed rape in the UK in 2012. Has received Annex 1 listing in the EU with approval extended until the ebnd of April 2024. The product is sold in most major cereal markets in Europe, the Americas and Australia. Introduced in Brazil for use on wheat in 2015 as Tricea. In 2016 Syngenta launched Serrate (clodinafop-propargyl, pyroxsulam) in Spain for use on cereals. In 2017 Dow’s Rexade (pyroxsulam, halauxifen-methyl) and Crusader GoDRI (pyroxsulam) for use on triticale and wheat (excluding Durum). | | | | | |

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| **Quinalphos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 80 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Ekalux) | Chinoin, Gharda, FMC, Alchemie, UPL, Ficom | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 190-1000 |
| **Crops** | **Main Pests** | | |
| Cotton, F&V, Rice, Sugarcane | A wide of range of insects / mites | | |
| **Main Mixture Partners :** beta-cypermethrin, mineral oil | | | | | |
| **Recent History:**  Commodity organophosphorous insecticide used on a range of crops. The product has been the subject of regulatory action in some developed markets and has not been re-registered in the EU, leaving that market in 2003. | | | | | |

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| **Quinclorac** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 90 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Facet) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 500-1000 |
| **Crops** | **Main Pests** | | |
| Rice, Turf | Grasses | | |
| **Main Mixture Partners :** cinosulfuron, pretilachlor | | | | | |
| **Recent History:**  Quinoline carboxylic acid herbicide for the control of barnyard grass (*Echinochloa* spp.) in transplanted rice. Used as a ‘one-shot’ with cinosulfuron and pretilachlor in Japan. Also finds some sales in spring wheat for the control of foxtails (*Setaria*) in the USA. Not re-registered in the EU. Introduced for use on barley, canola, and pasture in the USA, and for use on turf in 2003 as Drive. In 2010 Nufarm launched Quinclorac SPC 75DF in the USA for use on residential and ornamental turfgrass, whilst FMC received US EPA registration for SquareOne for use on lawns, golf courses, sod farms and athletic fields. | | | | | |

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| **Quinmerac** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | 160 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Fiesta) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 250-1000 |
| **Crops** | **Main Pests** | | |
| Rape, Sugarbeet | Broadleaved weeds | | |
| **Main Mixture Partners :** metazachlor, chloridazon, phenmedipham, dimethenamid | | | | | |
| **Recent History:**  Substituted quinoline carboxylic acid herbicide for broadleaved weed control, especially *Gallium aparine* (cleavers). Main use is in mixtures with metazachlor for use on oilseed rape (Novall/Katamaran) and chloridazon for use on sugarbeet (Rebell). In 2012 BASF received approval in Germany for the product in a mixture with metazachlor and imazamox as Clearfield Vantiga for use on Clearfield Canola. Re-registered in the EU with approval extended until the end of April 2021. | | | | | |

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| **Quinoclamine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other | <10 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Agro-Kanesho (Motogen) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** indanofan, halosulfuron, butachlor | | | | | |
| **Recent History:**  Naphthaquinone herbicide with fungicide and algicidal activity, used for the control of broadleaf weeds and algae in paddy rice. Now sold in export markets with a range of different applications. Also a constituent of ‘one-shot’ products in Japan, including with indanofan and halosulfuron as Agrohitter Gr and with butachlor was also launched as Arkace Gr. Received Annex 1 approval in the EU with approval extended until the end of December 2018. | | | | | |

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| **Quinoxyfen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Quinoline | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Fortress, Quintec, Arius) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 150-250 |
| **Crops** | **Main Pests** | | |
| Vine, F&V, Cereals | Powdery mildew | | |
| **Main Mixture Partners :** fenarimol, fenpropimorph | | | | | |
| **Recent History:**  Residual fungicide for the prevention of powdery mildew in cereals, with usage being extended to vines, cherries, melons, hops, and other fruit crops. Offered a new mode of action at the time of introduction, in which the spores of powdery mildew germinate, but are incapable of penetrating the plant. The product is sold under many brand names for different uses in several countries, with a number of mixture formulations also marketed, notably with fenarimol and fenpropimorph. Registered for fruit use (grapes, hops, and cherries as Quintec) and vegetables (Arius) in the USA in 2004. Received Annex 1 registration in the EU with approval currently valid until April 2018. | | | | | |

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| **Quintozene** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite -Other | <10 | 1950 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Terrachlor, Turfcide) | Bayer, Mitsui Chemicals, Amvac | | |
| **Application** | **Timing:** | Seed treatment, Soil applied, Foliar | **Rate – (g/ha):** 1100-33600 |
| **Crops** | **Main Pests** | | |
| Potato | Black scurf | | |
| Peanuts, F&V, Turf, Ornamentals | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pentachloronitrobenzene commodity fungicide for soil borne diseases on turf, ornamentals and vegetables. Active against *Rhizoctonia solani*, *Sclerotium* spp. and *Sclerotinia* diseases. EU registration was withdrawn in 2002 and most uses were also withdrawn in US, although the product is still used on brassicas and ornamentals under certain restrictions. Amvac acquired the quintozene product line from Chemtura in 2007. Gained re-registration for use in Canada and is currently under review in the USA. | | | | | |

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| **Quizalofop** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | 155 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Targa, NC 302) | DuPont, Gowan, Adama, BASF | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rape, Soybean, F&V, Rice, Sunflower, Cotton, Potato | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  One of the most active post-emergence graminicides for use on a wide range of broadleaf crops, marketed by DuPont as Assure in the USA and by a number of companies in Europe. Now largely replaced by the resolved form quizalofop-P. Turnover has declined in the USA due to the uptake of herbicide tolerant crops. Has not been re-registered in the EU, although quizalofop-p has achieved re-registration. Gowan introduced quizalofop-p in the USA in 2005 under license from Nissan and in competition with DuPont. In 2014 BASF commenced marketing the product for use on Clearfield rice. Also in 2014, Dow AgroSciences received US approval for its Enlist E3 corn and soybean trait, which is tolerant to 2,4-D and aryloxyphenoxypropionate graminicides such as quizalofop. In 2016 Gowan entered into an agreement with Nissan whereby the company will distribute certain formulations of quizalofop-P-ethyl in the UK. | | | | | |

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| **Quizalofop-P-tefuryl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Aryloxyphenoxypropionate | <30 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta LifeScience (Pantera, Rango, Logico) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** (30-150 |
| **Crops** | **Main Pests** | | |
| Rape, Sunflower, F&V, Sugarbeet | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Post-emergence graminicide structurally related to quizalofop-P. Primarily marketed in Europe for use on rape and sunflower. The product benefits from being one of the best in the class against perennial weeds. Sales have been impacted by the uptake of Roundup Ready crops, although recent sales growth has been driven by gains in East Europe. The product has gained EU approval with use extended until the end of November 2019. Manufactured by Chemtura, now part of Arysta LifeScience following the acquisition by Platform Specialty Products. | | | | | |

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| **Rimsulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 120 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Titus) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 40 |
| **Main Crops** | **Main Pests** | | |
| Maize, F&V, Potato, Vine | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :**  dicamba, mesotrione, terbuthylazine, thifensulfuron-methyl, bromoxynil, s-metolachlor, nicosulfuron, metribuzin | | | | | |
| **Recent History:**  Post-emergence sulfonylurea herbicide for annual and perennial grasses and some broadleaved weeds in maize, with lesser sales in fruit & vegetables and potato. Originally developed for sale in Europe where DuPont was precluded from marketing nicosulfuron; however the company are now able to launch nicosulfuron in the European market. Adama acquired the UK marketing rights for the product in 2004. Has received full Annex 1 re-registration in the EU with approval extended until the end of April 2018. Also marketed in the USA, predominantly in mixtures, notably with nicosulfuron as Principal. Other mixture products include with thifensulfuron as Basis; with dicamba as Titus Plus; with mesotrione as Realm Q and Instigate for use on maize; with thifensulfuron-methyl as LeadOff for use on maize, soybeans and cotton or Resolve Q for use on corn; and with metribuzin as Titus Pro in Canada for use on potatoes. In 2013 Cheminova (now part of FMC) launched the combination product Crusher in the US, which also contains thifensulfuron-methyl, for pre-plant and pre-emergence use on maize, and pre-plant use on soybeans, cotton and peanuts. In 2014 Cheminova launched the solo formulation Bestow and the mixture formulation Harrow (rimsulfuron with thifensulfuron-methyl) for use on maize in the USA. In 2017 DuPont launched Destra IS (rimsulfuron, mesotrione) and Sortan IS (rimsulfuron) in Canada, both for broadleaf weed control in corn. | | | | | |

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| **Saflufenacil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | 160 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Heat, Sharpen, Kixor) |  | | |
| **Application** | **Timing:** | Ppi, Pre- or early post-emergence | **Rate – (g/ha):** 36-143 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Maize, Sugarcane, Cereals | Pre-plant burndown control of broadleaf weeds | | |
| Non-crop, Orchards | Residual control of broadleaf weeds | | |  | |
| **Main Mixture Partners:** glyphosate, dimethenamid-P, imazethapyr | | | | | |
| **Recent History:**  Protoporphyrinogen oxidase (PPO) inhibitor which acts by blocking chlorophyll biosynthesis. Utilised alone or in mixtures with glyphosate for burndown weed control, with foliar and residual activity against more than 70 broadleaf weeds. In 2014 usage was extended to include use as a harvest aid and desiccant on peas, dry beans, sunflowers and soybeans in Canada. Introduced as Heat in Nicaragua, Chile and Argentina in 2009, and in several products in the USA in the same year: Sharpen (for use on several crops including cereals, corn, cotton and soybeans); OpTill (saflufenacil and imazethapyr for pre-plant and pre-emergence use on soybeans, chickpeas and peas); Integrity (saflufenacil and dimethenamid-p for maize); and Treevix (for citrus, pome fruit and nuts). Introduced in Canada in 2010 with dimethenamid as Integrity for maize, and as Eragon for soybeans. Optill gained a further approval in Canada for use on soybeans in 2013, with Heat introduced in Brazil in the same year. Approved in the USA in 2012 as Sharpen for use on rice. Sharpen has also been introduced in Brazil and Australia for arable and non-crop use. BASF has recently undertaken a number of investments to increase its manufacturing capacity of the product at sites in the USA and Brazil. In 2017 Detail (saflufenacil) proposed approval in Canada for use on non-crop land. | | | | | |

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| **Sedaxane** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | 65 | 2011 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Vibrance) |  | | |
| **Application** | **Timing:** | Seed Treatment | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Cereals, Soybean, Maize | Broad spectrum (*Botrytis, Alternaria, Anthracnose, Venturia, Sclerotinia, Fusarium*) | | |
| **Main Mixture Partners:** difenoconazole, fludioxonil, thiamethoxam, metalaxyl-m | | | | | |
| **Recent History:**  Fungicide developed as SYN524, active by inhibition of succinate dehydrogenase. Marketed as Vibrance, the product was developed by Syngenta specifically for use as a seed treatment and provides control of a broad spectrum of diseases, as well as reportedly protecting against seed infection. Introduced in Argentina in 2011 in a mixture with difenoconazole, fludioxonil and thiamethoxam for use on cereals. This was followed in 2012 by Vibrance Gold, with difenoconazole and fludioxonil for use on cereals in France. Has since been introduced in a wide range of other combination products and in several crops, including as part of Syngenta’s Cruiser Maxx range with thiamethoxam, fludioxonil and metalaxyl-m. US approval of Vibrance has since been extended from cereals to a wide range of other crops, including Clariva Complete Beans (thiamethoxam, sedaxane, fludioxonil and metalaxyl-m), which also provides control of soybean cyst nematodes (*Heterodera glycines*). Has also been approved in Australia, and has received EU registration with approval currently valid until the end of January 2024. Rizobacter acts as the exclusive supplier of sedaxane-based seed treatment products in Argentina, launching Compinche SX and Tenacius SX for use on cereals in the country in 2015. Syngenta launched Visivio (thiamethoxam, sulfoxaflor, difenoconazole, metalaxyl-M, fludioxanil and sedaxane) in Canada in 2016. In 2017 CruiserMaxx Vibrance (sedaxane, thiamethoxam, fludioxonil, difenoconazole) in the US as a potato seed treatment. | | | | | |

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| **Sethoxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | 40 | 1981 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Nabu) | BASF (Poast) | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100-400 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Peanuts, Cereals, Potato, Maize | Grass weeds | | |
| **Main Mixture Partners :** imazethapyr | | | | | |
| **Recent History:**  Once one of the leading post-emergent graminicides used on many broadleaf crops, with the main markets being soybeans and cotton in the USA, both of which have been affected by the uptake of herbicide tolerant varieties. Usage was expanded to maize through the introduction of Poast Protected varieties, although this has now largely been removed from the market. Has not been re-registered in the EU; however BASF and Nippon Soda have since registered tepraloxydim. Has been re-registered in the USA. In 2015 Bayer launched Odyssey Ultra B for use on Clearfield canola and lentils, as well as peas and soybean. BASF’s Odyssey Ultra was granted usage expansion in Canada for use on faba beans. | | | | | |

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| **Silafluofen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Others | <30 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Mr. Joker) | None | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Brown plant hopper, Leaf rollers, Water weevil | | |
| F&V, Plantation Crops | A wide range of insects | | |
| **Main Mixture Partners :** ferimzone, phthalide | | | | | |
| **Recent History:**  Broad-spectrum silicon-containing soil applied insecticide/termiticide. Originally developed by Aventis and now part of the Bayer portfolio. Has not been approved for use in the EU. | | | | | |

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| **Silthiofam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Carboxamide | <30 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Latitude) | None | | |
| **Application** | **Timing:** | Seed Treatment | **Rate – (g/ha):**  Approved rate 5-40g/100kg seed,  Actual rate 25g/100kg seed |
| **Main Crops** | **Main Pests** | | |
| Cereals | Take-all | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Registered in Ireland in 1999 and Poland, Belgium, UK, Germany, South Africa and China in 2000. Has received Annex 1 approval in the EU with approval valid until the end of October 2017. Reported to provide good control of the cereal disease take-all, particularly on susceptible wheat varieties. A number of competing products for take-all control have since been introduced. | | | | | |

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| **Simazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | <30 | 1956 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Primatop, Princep, Gesatop) | Adama, Oxon, Dow, Atanor, Meghmani | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence | **Rate – (g/ha):** 1000-3200 |
| **Main Crops** | **Main Pests** | | |
| Maize, F&V, Rape | Grasses, Broadleaved weed | | |
| **Main Mixture Partners :** atrazine, amitrole, paraquat, glyphosate | | | | | |
| **Recent History:**  Commodity triazine herbicide with activity against many annual grasses and broadleaved weeds. A mature product whose future sales are likely to be limited by regulatory action due to groundwater concerns. Lost its registration in the EU in 2003. | | | | | |

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| **Simeconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | <10 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals (Mongarit, Sanlit) | None | | |
| **Application** | **Timing:** | Foliar,  Seed Treatment | **Rate – (g/ha):** 250- 700 |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice, Turf | Rice sheath blight (450-600), Turf Rhizoctonia rot (250), Fruit Diseases (100-700) | | |
| **Main Mixture Partners :** mancozeb, isoxathion | | | | | |
| **Recent History:**  Introduced in Japan for use on turf to control *Rhizoctonia* diseases as Patchikoron in 2001. Introduced in 2003 as Sanlit for use on fruit and tea, and as Mongarit, a 1.5% granule formulation for rice. Mixture products with mancozeb for top fruit and vegetables and isoxathion for soybeans were also introduced in 2003. Active against scab, rust and powdery mildew on pome fruits and Blossom blight and Alternaria blotch on apples, as well as brown rot on peaches. Wettable powder formulations were introduced in 2004, including mixture products with mancozeb and isoxathion. Global rights outside some Asian and Middle East countries were acquired by FMC from Sankyo in 2007, although FMC discontinued its efforts to develop the product in 2008. Now part of Mitsui Chemicals following the acquisition of Sankyo Agro. In 2017 Mitsui launched Triplekick G (simeconazole, tolprocarb, cyantraniliprole) in Japan for rice nursery box treatment. | | | | | |

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| **Spinetoram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural product | 210 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Delegate, Radiant) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200 - 400 |
| **Main Crops** | **Main Pests** | | |
| F&V, Nuts, Rice, Pome fruit | Lepidoptera, including Codling moth, Oriental fruit moth, leafrollers, leafminers, thrips  Pear psylla | | |
| Tea | *Spodoptera* spp., loopers, heliothines, thrips, leafminers (*Liriomyza* spp.), diamondback moth | | |
| **Main Mixture Partners :** methoxyfenozide, clothianidin, isotianil | | | | | |
| **Recent History:**  Spinosyn analogue that provides broad-spectrum control of key pests for tree fruit, tree nut, vine and vegetable crops with minimal impact on beneficial pests. First registered in 2007 in New Zealand for use on pome fruit as Delegate WG, and in the USA and Canada as Delegate WG for fruit and nut trees and Radiant SC for vegetables. Approval for Delegate in the US was extended to the control of grapevine moth on vines in 2010. Introduced in Mexico and Colombia in 2009. Has received registration in the EU with approval extended until the end of June 2024. Sumitomo Chemical launched the product in Japan in 2011. Dow received US approval for the product in a mixture with methoxyfenozide as Intrepid Edge for use on soybeans, peanuts and pecans in 2013. Gained approval in Brazil in 2013 for use on a range of crops including soybeans and maize. In 2015 Dow launched Exalt in Brazil for use on soybeans to combat various pests including earworms and soybean loopers. | | | | | |

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| **Spinosad** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural Product | 310 | 1995 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Naturalyte, Tracer) | None | | |
| **Application** | **Timing:** | Foliar, Seed Treatment | **Rate – (g/ha):** 50-100 |
| **Main Crops** | **Main Pests** | | |
| F&V | A wide range of insects | | |
| Cotton | Bollworm complex, Other Lepidoptera | | |
| Maize | European corn borer, Cutworm, Armyworm, Cornstalk borer | | |
| Soybean, Vine, Potato | A wide range of insects | | |
| **Main Mixture Partners :** bifenthrin, zeta cypermethrin thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, isotianil, imidacloprid | | | | | |
| **Recent History:**  Broad-spectrum insecticide derived from the fungus *Saccharopolyspora spinosa,* initially targeted for use in cotton, where it is intended to complement *B.t.* varieties, fruit & vegetables and vine, with usage now expanded to a range of other crops. The product is positioned alongside spinetoram, with each product having a different spectrum of activity. Has received approval in the EU until the end of April 2018, where it has also been approved for use on organic crops. In 2010 Syngenta launched the product in the USA as a component of its FarMore FI500 seed treatment in combination with thiamethoxam, mefenoxam, fludioxonil and azoxystrobin. Nissan Chemical launched the product in Japan a mixture with isotianil, imidacloprid and thifluzamide as Shario for use on rice in 2012. Also finds usage in non-crop markets, including for use as fly bait in poultry houses and canine antiparasitic products. In 2015 Scotts receive approval for its Ortho Home Defense Max ant bait station in Canada. In 2017 Spindle (spinosad) was granted registration in Brazil for use on vines, coffee and apples. | | | | | |

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| **Spirodiclofen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 120 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Envidor, Daniemon) | None | | |
| **Application** | **Timing:** | All stages | **Rate – (g/ha):** 50-200 g ai/1000 litres |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Nuts, Vine | Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum acaricide based on ketoenol chemistry, active through inhibition of lipid synthesis with activity against eggs, larvae, nymphs and quiescent stages, but slightly less active against adults. Approved in South Korea, South Africa, Brazil, Colombia, and Switzerland in 2002 for introduction in 2003. Registered in Japan and the Netherlands in 2003. Has received Annex 1 approval in the EU until the end of July 2020. Launched in the US and Canada in 2005, introduced as Envidor in Italy in 2007, and launched in Spain and Chile in 2008. | | | | | |

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| **Spiromesifen** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | 75 | 2005 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Oberon, Forbid) | None | | |
| **Application** | **Timing:** | All stages of mites | **Rate – (g/ha):** 100-150 |
| **Main Crops** | **Main Pests** | | |
| F&V, Soybean, Cotton | White fly, Spider mites | | |
| **Main Mixture Partners :** abamectin, bifenazate | | | | | |
| **Recent History:**  Insect growth regulator active via a novel mode of action -the interference of lipid biosynthesis. Particularly active against juvenile stages of mites, whilst also reducing the fecundity (ability to reproduce) of adult pests. Gained its first registrations in the UK and Indonesia in 2003, followed by the USA, Mexico, and Netherlands in 2005. Has since been introduced in a number of crop and country markets, including as Oberon in Spain for use on strawberries in 2011, and in Italy in 2012 for ornamentals and horticultural crops. Has received registration in the EU. Bayer has also launched Oberon Speed (spiromesifen with abamectin) in some country markets, including in Guatemala in 2015 for the control whitefly and mites on vegetable crops and melon. Dhanuka Agritech launched the product as Danfuron in India in 2013. | | | | | |

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| **Spirotetramat** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other - Ketoenol | 180 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure:** | |
| Bayer (Movento, Ultor) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 70-170 |
| **Main Crops** | **Main Pests** | | |
| F&V, Vine, Potato, Cotton | Sucking pests | | |
| **Main Mixture Partners :** thiacloprid | | | | | |
| **Recent History:**  Third ketoenol analogue from Bayer following on from spirodiclofen and spiromesifen which are both predominantly contact active miticide products. Offers systemic activity, with the mode of action, inhibition of insect lipid biosynthesis, new at the time of introduction. Provides broad-spectrum control of sucking insects including aphids, whitefly, scale insects and mealy bugs on a wide range of crops. The first approval was achieved in Tunisia in 2007, with this being followed by the USA and Canada in 2008. Has since been introduced in a number of other country markets, including China, Colombia, Mexico, Turkey, Chile, New Zealand, the UK and Australia, and has been approved in the EU until the end of April 2024. Bayer gained approval for the importation of the product into Japan in 2010, and launched a formulation with thiacloprid as Movento Smart in Chile in 2011. | | | | | |

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| **Spiroxamine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI –Morpholine | 155 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Impulse, Prosper, Accrue) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 500-750 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Vine, F&V | Powdery mildew | | |
| **Main Mixture Partners :** prothioconazole, tebuconazole, triadimenol, bixafen | | | | | |
| **Recent History:**  Spiroketalamine fungicide active via inhibition of sterol biosynthesis, offering protective and curative control of powdery mildew. Although not a morpholine, it has been placed in that class due to the similarity of action. Also provides moderate control of both yellow and brown rust, and *Rhynchosporium* on cereals. The product has received Annex 1 registration in the EU with approval extended until the end of 2021. Introduced as Impulse in Central America in 2005 for use on bananas, the product has since been introduced as Prosper for use on vines in Europe, South Africa, Canada, Australia and Israel. In 2010 Sumitomo’s UK subsidiary Interfarm gained the UK marketing rights for the product in a mixture with tebuconazole as Thyme. In 2015 Bayer launched Soligur (spiroxamine, prothioconazole and tebuconazole) in Morocco for the control of various cereal diseases and Impulse for black sigatoka control on bananas in Ecuador. In 2017 Spirox (spiroxamine) was introduced in Croatia for use on grapevines. | | | | | |

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| **Streptomycin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Antibiotic | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Agri-Strep) | Amvac, FarmHannong | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-20 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Potato | Gram-positive bacterial diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Plant bactericide used in niche markets including the control of fire blight of pears and apples. Of limited commercial significance, and not registered in the EU. Sold in the USA by Cerexagri (UPL) as Firewall to control fire blight and bacterial spot on fruit & vegetable crops. | | | | | |

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| **Sulcotrione** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <30 | 1990 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Mikado) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 200-450 |
| **Main Crops** | **Main Pests** | | |
| Maize | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** foramsulfuron, atrazine, pyridate, nicosulfuron | | | | | |
| **Recent History:**  Triketone broadleaved weed herbicide for maize with some grass weed activity. Bayer acquired the rights to the product from Syngenta in 2001. Sulcotrione then formed part of a total maize weed control strategy with metosulam and flufenacet, enhanced with the other products acquired as part of Aventis. Predominantly for the European market where it met with considerable success, but has now reached maturity. Has received full Annex 1 approval in the EU with approval extended until the end of August 2022. Formulated for use in tank mixes with atrazine, pyridate and nicosulfuron. Achieved registration in the USA and is now sold in most regions of the world, although Europe remains the most significant. | | | | | |

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| **Sulfentrazone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | PPO - Others | 210 | 1996 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Authority) | None | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 430 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Soybean, Sunflower | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** chlorimuron-ethyl, cloransulam, clomazone, halosulfuron, metribuzin | | | | | |
| **Recent History:**  PPO herbicide which provides pre-plant incorporation and pre-emergence control of broadleaved weeds (particularly water hemp and black nightshade) as well as some grasses and sedges. Developed and introduced by FMC, once marketed by DuPont for use on soybeans in several markets, but no longer on an exclusive basis. Mainly used in mixtures, particularly with cloransulam (as Gauntlet) and clomazone (as Command Extra) and positioned to complement sulfonylureas on STS beans. Also introduced for use in sugarcane, sunflower, pineapple and tobacco as Spartan by FMC, and has been licensed out for non-crop markets. In 2010 FMC launched Authority XL, a mixture with chlorimuron, for use on soybeans. Authority 480 received Canadian approval in 2011, and Authority Maxx, a mixture with chlorimuron-ethyl, received US approval in 2013. In 2010 sulfentrazone entered Monsanto’s Roundup Ready Plus program for the control of glyphosate resistant weeds, which has led to significant sales growth in recent years. Has not been approved for use in the EU. In 2017 Vandal MOC (sulfentrazone, metolachlor) was approved in the US for use on soybean, sunflower and dry shelled peas. In 2017 FMC launched Stone (sulfentrazone, diuron) in Brazil for use on sugar cane. | | | | | |

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| **Sulfometuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 1982 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont/Bayer (Oust, Curavial) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 30-630 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** chlorsulfuron, diuron, hexazinone | | | | | |
| **Recent History:**  Mature, broad-spectrum sulfonylurea herbicide. Formulation with chlorsulfuron was introduced in 2003 as Landmark for use in forestry, turf grass and other non-crop sectors. The product is used under the name Curavial in Brazil for use on sugarcane. In 2015 Bayer acquired DuPont’s land management business in the USA, Canada, Mexico, Australia and New Zealand, comprising a portfolio of around 30 products, including Oust. | | | | | |

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| **Sulfosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 40 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Monsanto (Leader, Monitor) | Rallis, Atul, Meghmani, Sumitomo Chemical | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 10-35 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Sulfonylurea herbicide for pre- and post-emergence control of grass weeds, also offering control of some broadleaved weeds on winter soft wheat. Co-developed by Takeda and Monsanto and introduced in most major cereal-producing markets. Offers good control of brome. Received Annex 1 registration in the EU. Philagro has the distribution rights for the product on wheat in France. Used in India for the control of canary grass, where it is sold as Leader by Sumitomo Chemical following its purchase from Monsanto in 2006. | | | | | |

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| **Sulfoxaflor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other (Sulfoximine) | 105 | 2012 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Expedition, Isoclast, Transform) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 12-150 |
| **Crops** | **Main Pests** | | |
| Turf, Soybean, Cotton, Cereals, F&V | Sap feeding insects | | |
| **Main Mixture Partners:** lambda-cyhalothrin | | | | | |
| **Recent History:**  Aimed at the control of sap-feeding pests such as aphids, whiteflies and planthoppers in high-value crops, notably Lygus bugs on cotton and brown planthopper on rice. Active as an agonist of the nicotinic acetylcholine receptor in the insect’s nervous system. Reportedly provides broad-spectrum control at low use rates. First introduced in South Korea in 2012, with subsequent registrations in Panama, Indonesia, Guatemala and Vietnam, where Dow launched Closer in a distribution partnership with Arysta in 2013 for use on rice. Approved in the USA in 2013 for use on cotton, canola, soybean, cereals, F&V and turf, as well as in Canada and Australia. Dow received US approval for Seeker, also containing lambda-cyhalothrin, in 2014 for use on wheat, canola and soybeans. Isoclast gained approval for use on cereal and vegetable crops in the EU and for vegetables, cereals, oilseeds, and fruit and nut crops in Canada in 2015. In 2015 the US EPA cancelled registration of the product in the country through concerns over bee health. In 2017 Transform (sulfoxaflor) gained Australian registration for use on macadamia and avocado. | | | | | |

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| **Sulfuryl Fluoride** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | Fumigant | 35 | 1961 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Douglas Products (Vikane, ProFume) | Chinese Companies | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Non-crop | Insects and Rodents | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Gas fumigant currently used for fumigation of buildings. Approved for food usage (cereals, dried fruit and nuts) in 2004 as ProFume in the USA as a methyl bromide replacement. Received Swiss approval in 2003, followed by approval in the UK and Italy in 2004. ProFume use in the USA was extended to cover food-processing facilities in 2005 and buildings, storage, silos and warehouses in 2007. The first biocidal active ingredient to be awarded full EU approval after clearing this process in 2006 for use as a wood preservative and insecticide. Granted full EU approval for use as a non-crop insecticide/nematicide in 2009. Gained approval in Canada in 2007 as a fumigant for empty facilities. In 2015 Dow divested its sulfuryl fluoride post-harvest and structural fumigant business to Douglas Products. | | | | | |

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| **Sulphur** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Inorganic | 195 | 1880 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure**  **S** | |
| UPL (Sulfur) | Syngenta, BASF, Cuproquim, Sulphur Mills, Excel Crop Care, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 2400-10000 |
| **Main Crops** | **Main Pests** | | |
| Vine, F&V, Pome fruit | Range of diseases including Exocoriosis, Powdery mildew, Mites, Cotton rust, Rusts | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Elemental sulphur has long-standing basic crop protection usage for the control of both diseases and mites of vines, fruit, vegetables and citrus. Sulphur has contact activity particularly against powdery mildew, scab, and mites. Marketed in basic powder form and also in more advanced micronised formulations, predominantly by companies who mine the product. Engage Agro USA and Sulphur Mills entered into a product development agreement regarding certain Sulphur Mills products in the USA during 2015. | | | | | |

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| **Tebuconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 575 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Prosaro, Folicur, Raxil) | Adama, Meghmani, Atul, Punjab Chemicals, Rotam | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 125-375 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Brown rust, Leaf blotch, Net blotch, Septoria leaf spot | | |
| Rape, F&V, Rice, Plantation crops | A wide range of diseases | | |
| Soybean | Asian Rust, Brown spot / Septoria leaf blight, others | | |
| Maize | Leaf blight | | |
| Vine | Powdery mildew, *Botrytis*, Black Rot | | |
| **Main Mixture Partners :**  fenpropidin, propiconazole, tolylfluanid, imidacloprid, triazoxide, triadimenol, triadimefon, spiroxamine, prochloraz, prothioconazole, pyraclostrobin, fluoxastrobin, spiroxamine, trifloxystrobin, fluopyram, kresoxim, carbendazim | | | | | |
| **Recent History:**  Provides broad-spectrum disease control, primarily on cereals. One of the leading triazole fungicides, but sales have been impacted by significant generic competition. Used through both foliar application and in seed treatments, primarily in combination with other products, including fluoxastrobin, prothioconazole, trifloxystrobin, kresoxim, carbendazim and fluopyram. Has achieved re-registration in the EU with approval extended until the end of August 2019. Recent generic introductions include SipcamAdvan’s Clearscape in the USA in 2013; Adama’s Custodia, with azoxystrobin, for use on US wheat, maize and soybeans; Innvictis Crop Care’s Crossover; and Rotam’s Ykatu, with azoxystrobin, for soybeans in Argentina and Brazil. In 2014 Bayer launched Raxil Pro Shield in Canada, a mixture of Raxil Pro (tebuconazole, metalaxyl and prothioconazole), and the insecticide Stress Shield 600 (imidacloprid). In 2015 Bayer gained an extension to Nativo (trifloxystrobin and tebuconazole) for use on sugarcane in Brazil, Bayer’s first fungicide for use on the crop. In 2016 Bayer launched Absolute Maxx (also containing trifloxystrobin) and Provost Opti (a mixture with prothioconazole) in the USA. In 2017 Cronnos (picoxystrobin, tebuconazole and mancozeb) was launched in Brazil by Adama for use on soybean. | | | | | |

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| **Tebufenozide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other IGR | <30 | 1993 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Mimic, Confirm) |  | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, Rice, F&V, Pome fruit, Vine | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  First of the moult accelerating compound (MAC) insect growth regulators to reach the market, and now introduced on a wide range of crops. Selective to larvae of Lepidoptera on a range of fruits, vegetables and field crops. The product has been introduced in most major markets. Now part of the Nippon Soda portfolio following its acquisition from Dow AgroSciences in 2010. Dow had been replacing the product with methoxyfenozide (lower application rate, broader spectrum of activity) in some markets, particularly cotton. In 2010 Gowan acquired the US and Canadian marketing rights to Confirm from Nippon Soda. In the same year, Certis Europe was appointed by Nippon Soda as the distributor of tebufenozide in France, Italy, Spain, Portugal, the UK, the Netherlands and Luxembourg. Valent BioSciences market the product as Mimic in the Canadian and US forestry markets. Re-registered in the EU until May 2021. | | | | | |

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| **Tebufenpyrad** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Acaricide | <30 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (Pyranica) | BASF (Masai) | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 25-200 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Vine | Mites | | |
| **Main Mixture Partners :** bifenthrin | | | | | |
| **Recent History:**  Pyrazole carboxamide acaricide active against all stages of mites. Co-developed with Cyanamid (now BASF) who have introduced the product in many European markets as Masai. The product's main use is on fruit with activity against *Tetranychus, Panonychus, Oigonychus* and *Eotetranychus* spp. Introduced by Mitsubishi Chemical and now part of Nihon Nohyaku. Introduced by Platte Chemical for greenhouse ornamentals in the USA in 2002. Achieved re-registration in the EU until October 2022. | | | | | |

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| **Tebufloquin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Quinoline | <10 | 2013 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Meiji Seika | None | | |
| **Application** | **Timing:** |  | **Rate – (g/ha):** |
| **Crops** | **Main Pests** | | |
| Rice, Soybean, F&V | Blast, Leaf Spot, Range of diseases | | |
| **Main Mixture Partners:** dinotefuran, ethiprole, etofenprox | | | | | |
| **Recent History:**  Developed by Meiji Seika as AF-02 and SN 4524 and introduced in Japan by Kumiai in 2013 in combinations with dinotefuran and ethiprole under the brand Try. | | | | | |

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| **Tebupirimfos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Aztec) | None | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Maize | Corn rootworm, Seedcorn maggot, Wireworm | | |
| **Main Mixture Partners :** cyfluthrin | | | | | |
| **Recent History:**  Organophosphorous insecticide for the control of corn rootworm (*Diabrotica* spp.). Marketed in a mixture with cyfluthrin as Aztec, offering control of rootworm, wireworm and cutworms on maize. Accepted for use in the USA, although not used in the EU. Amvac acquired the product, including all registrations and data rights, manufacturing and formulation know-how, and inventories, as well as the trademarked brand names Aztec, Azteca and Capinda from Bayer in 2010. | | | | | |

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| **Tebuthiuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Urea | 75 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nutrichem (Spike, Lava) | Adama | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 1000-6800 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane | Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Urea herbicide for total vegetation control including brush and woody plants, primarily used on sugarcane with some usage on pastures and rangeland. Acquired by the Chinese company Nutrichem in 2016 from Dow. Not re-registered in the EU and left that market from July 2003. Adama received approval for generic tebuthiuron in Brazil for use on sugarcane in 2005, followed by a similar approval for Volcano in 2006. Predominately sold throughout Latin America under the brand name Lava. Gained approval in 2015 for use in China. In 2017 Chinese agrochemical company [Beijing Nutrichem](https://www.agra-net.com/agra/agrow/companies-business/mergers-and-acquisitions/nutrichem-to-purchase-dows-tebuthiuron-business-517272.htm) agreed to acquire Dow AgroSciences' tebuthiuron herbicide business. | | | | | |

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| **Tecloftalam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <10 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals  (Shirahagen-S) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** 100-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Bacterial disease | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Preventative and curative antibiotic treatment for bacterial leaf blight (*Xanthomonas* spp.) of rice. | | | | | |

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| **Teflubenzuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 135 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Nomolt) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 30-150 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Maize, F&V, Cotton | A wide range of insects and mites. | | |
| **Main Mixture Partners :** indoxacarb, alpha-cypermethrin | | | | | |
| **Recent History:**  Benzoylurea insect growth regulator introduced by Shell and acquired by BASF as part of the Cyanamid portfolio. Broad range of pest and crop coverage, particularly for mosquito larvae and locust control. Suffers from lack of miticidal activity hence a minor product in the class. Achieved re-registration in the EU with approval extended until the end of November 2019. Approved in Brazil and Argentina in 2007 in a combination with alpha-cypermethrin as Imunit for use on cotton, maize and soybeans. | | | | | |

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| **Tefluthrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 135 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Force) | None | | |
| **Application** | **Timing:** | Soil applied,  Seed treatment | **Rate – (g/ha):** 600-800 |
| **Main Crops** | **Main Pests** | | |
| Maize | Corn Rootworm, Cutworm, Cornstalk Borer, Seedcorn Maggot, Wireworm | | |
| F&V | A wide range of insects, mites and nematodes. | | |
| **Main Mixture Partners :** thiamethoxam, imidacloprid | | | | | |
| **Recent History:**  Pyrethroid insecticide active via soil application against a range of pests including corn rootworm. The only soil active pyrethroid that is used as a soil insecticide in NAFTA and Europe, and also in a more limited way on cereals and sugarbeet in Europe. An important part of Syngenta’s insecticide portfolio, although sales on maize in the USA have been impacted by the introduction of *B.t.* maize tolerant to corn rootworm. Also sold by Bayer in combination with imidacloprid. Amvac have supplied the product through their SmartBox delivery system since 2004. Re-registered in the EU until the end of 2021 following its resubmission for approval. In 2013 Syngenta launched the product in a mixture with thiamethoxam as Excelto in Chile for control of aphids on barley and wheat. In 2017 Syngenta received approval for Force Evo, which will replace Force CS in the US in the 2018 growing season, the new formulation is compatible with 47 liquid starter fertilisers. | | | | | |

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| **Tefuryltrione** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | <30 | 2008 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer / Hokko (Bodyguard, Possible) |  | | |
| **Application** | **Timing:** | Pre-emergence, post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Annual and perennial broadleaf weeds and sedges | | |
| **Main Mixture Partners:** fentrazamide, mefenacet, pyraclonil, triafamone | | | | | |
| **Recent History:**  Co-developed by Bayer and several companies in Japan. Active through the inhibition of hydroxyphenylpyruvate dioxygenase (HPPD) and is reportedly effective in the control of weeds which have developed resistance to sulfonylurea herbicides. Sold in mixtures with fentrazamide and with mefenacet. In 2010 Nissan received Japanese approval for the product in a mixture with pyraclonil as Get-Star. In 2014 Bayer received approval for Council, a combination product with triafamone, for use in South Korea, with similar approvals in other major rice-growing countries expected to follow. | | | | | |

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| **Tembotrione** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | 210 | 2007 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Soberan, Laudis) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 92 |
| **Main Crops** | **Main Pests** | | |
| Maize | Grasses, Broadleaf weeds | | |
| **Main Mixture Partners :** thiencarbazone-methyl, dicamba, isoxadifen | | | | | |
| **Recent History:**  Acts by inhibition of 4-hydroxyphenylpyruvate dioxygenase. Targeted at the mid to late post-emergence sector for broad spectrum weed control, complementing thiencarbazone which is used for early post-emergence grass weed control. Registered in the USA in 2007 in combination with the safener isoxadifen, followed by a number of other country markets, including in Brazil (2008) and Chile (2010) as Soberan, and in Portugal (2009), Greece (2011) and Italy (2012) as Laudis. The product has gained full EU approval subject to certain risk mitigation measures until the end of April 2024. The mixture product Capreno (tembotrione and thiencarbazone-methyl) was introduced in the USA in 2010. Bayer and Syngenta are currently co-developing strategies to target resistance to HPPD inhibitor herbicides such as tembotrione in soybeans. During 2016 Bayer launched DiFlexx Duo, a mixture with dicamba, in the USA for use on maize. | | | | | |

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| **Tepraloxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | <30 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF(Aramo),  Nippon Soda(Hoonest) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 25-100 |
| **Main Crops** | **Main Pests** | | |
| Soybean, F&V, Rape | Grass weeds | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Developed by the Nisso BASF joint venture as BAS 620H/NP 61EC. Claims to be the first graminicide active against meadow grass and also active against target site resistance in blackgrass, with good activity also reported against couch grass. First registered in Japan as Hoenest in 2000, and introduced in the UK (Aramo) and USA (Equinox) in 2001, with approval also being received in Switzerland and Belgium, followed by France and Germany in 2002 and Canada in 2007. EU approval had been extended to July 2017, however BASF voluntarily cancelled the extension, with registration expiring in May 2015. | | | | | |

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| **Terbacil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Others | <10 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Tessenderlo Kerley (Sinbar, Zobar) | None | | |
| **Application** | **Timing:** | Pre plant emergence | **Rate – (g/ha):** 450-4000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit | Grasses and Broadleaved weeds | | |
| **Main Mixture Partners :** linuron, diuron | | | | | |
| **Recent History:**  Residual broad-spectrum uracil herbicide used mainly on fruit crops. Also used in mixtures, notably with linuron on potatoes and with diuron on vines and fruit. Not re-registered in the EU and left that market in July 2003. Tessenderlo Kerley acquired the product from DuPont in 2007, including the manufacturing technology and the worldwide registrations and data packages, launching a new formulation of Sinbar in the USA and Canada in 2011. | | | | | |

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| **Terbufos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 40 | 1974 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Counter) | UPL, Chinese Companies | | |
| **Application** | **Timing:** | Soil applied | **Rate – (g/ha):** 500-2000 |
| **Main Crops** | **Main Pests** | | |
| Maize | Bill bug, Corn rootworm, Cutworm, Flea beetle, Seedcorn maggot, Thrips, Wireworm | | |
| Sugarbeet, F&V | A wide range of Insects and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Initially introduced for use on maize, this has now expanded to a broad range of crops subject to soil pest problems, notably sugarbeet. Not re-registered in the EU and left that market from July 2003, but cleared for re-registration in the USA and in Canada, although the 15G formulation can no longer be used on maize. Amvac acquired BASF’s global terbufos business in 2006. Chinese authorities have stopped accepting applications for field testing, registration or manufacturing permits and have withdrawn registrations and production licenses for the product, with these measures to lead to an eventual ban in the country. | | | | | |

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| **Terbuthylazine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | 70 | 1966 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Gardoprim, Lumax) | Adama, Oxon, Dow, Herbos, Meghmani, Shandong Weifang Rainbow Chemical | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 2500-3000 |
| **Main Crops** | **Main Pests** | | |
| Maize, Sunflower, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :**  mesotrione, s-metolachlor, rimsulfuron, thifensulfuron-methyl, terbutryn, bentazone, pyridate, nicosulfuron, foramsulfuron, iodosulfuron, dimethenamid, glyphosate, diuron, linuron, alachlor, pethoxamid | | | | | |
| **Recent History:**  Commodity broad-spectrum triazine whose main usage is in maize and in mixtures for many other crops. Not currently marketed in the USA, and finds most of its sales for use on maize in Europe. Re-registered in the EU in 2012 following its resubmission for approval, although the registration on the French vines market ended in 2003 due to groundwater concerns. Arysta’s Czech subsidiary distribute the product in a mixture with pethoxamid as Bolton Duo in the Czech Republic and Slovakia. In 2017 Syngenta launched Lumax (terbuthylazine, mesotrione, s-metolachlor) in Spain for use on maize. | | | | | |

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| **Terbutryn** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | <10 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Adama (Terbutrex) | Meghmani, Shandong Weifang Rainbow Chemical | | |
| **Application** | **Timing:** | Pre-plant incorporated,  Pre-emergence | **Rate – (g/ha):** 175-1400 |
| **Main Crops** | **Main Pests** | | |
| Sugarcane, F&V | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** terbuthylazine, ametryn | | | | | |
| **Recent History:**  Commodity broad-spectrum triazine herbicide for annual weed control. Mainly used in mixtures with a large range of partners. Not re-registered in the EU and left that market from July 2003, most registrations in the USA have also been cancelled. Syngenta no longer market the product, however Adama sell terbutryn in mixtures with a number of other herbicides. | | | | | |

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| **Tetraconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 60 | 1991 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Isagro (Eminent, Domark) | None | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cotton, F&V, Ornamentals | A wide range of diseases | | |
| Soybean | Asian, Rust, Brown spot / Septoria leaf blight, Leaf blight, Frogeye leaf spot, Powdery mildew | | |
| Vine | Black Rot | | |
| **Main Mixture Partners :**  carbendazim, chlorothalonil, prochloraz, sulphur, copper, fluoxastrobin | | | | | |
| **Recent History:**  One of the more active triazole fungicides, developed by Isagro. Sold in mixtures including with carbendazim, chlorothalonil, prochloraz, sulphur, and copper. Has EU approval extending until the end of December 2021. Domark received further registration in the USA for use on maize in 2012. Isagro’s Mettle product received registration in Canada in 2013 for use on vine and some other fruit and vegetables. Isagro also entered a supply agreement for the product with Cheminova (now FMC) in Spain in 2013. In 2014 Gowan became the exclusive distributor for Domark 230ME on corn and soybeans in the USA. In 2015 SipcamAdvan launched Minerva (tetraconazole) and Minerva Duo (tetraconazole and triphenyltin hydroxide) for the control of Cercospora leaf spot and powdery mildew in sugarbeet in the USA. In 2015 Arysta launched Xolera FX in the USA, a mixture with fluoxastrobin for use on maize and soybean crops. In 2017 Trevo TRZ (tetraconazole, azoxystobin) was launched in the US for maize, soybean and sugarbeet. | | | | | |

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| **Thenylchlor** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Acetamide | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| SDS Biotech (Alherb) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 180-270 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** bensulfuron, cyhalofop | | | | | |
| **Recent History:**  Chloracetamide herbicide for pre-emergence control of both grass and broadleaved weeds in paddy rice, particularly barnyard grass (*Echinochloa* spp.) up to the two-leaf stage. Used in numerous ‘one-shot’ mixtures, the most notable being Papika (with bensulfuron and cyhalofop) and Kusamets (with bensulfuron). Acquired by SDS Biotech from Tokuyama Soda in 2007. | | | | | |

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| **Thiabendazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Benzimidazole | 35 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Maxim, Mertect, Tecto) | Loveland, Pace | | |
| **Application** | **Timing:** | Seed treatment, Foliar, Post-harvest treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Maize, F&V, Plantation crops, Cereals | A wide range of diseases | | |
| **Main Mixture Partners :**  metalaxyl-M, fludioxonil, azoxystrobin, abamectin, thiamethoxam | | | | | |
| **Recent History:**  The first benzimidazole to be commercialised, a broad-spectrum fungicide with a wide range of crop applications. Usage has been limited by resistance development, but still finds sales for post-harvest disease control. In 2010 Syngenta gained US EPA approval for Maxim Quattro (a mixture with metalaxyl-M, fludioxonil and azoxystrobin) for seed treatment use on maize. Also in 2010, Syngenta launched a seed treatment containing Maxim Quattro in combination with abamectin and thiamethoxam as Avicta Complete for use on SmartStax maize hybrids. Has achieved Annex 1 listing in the EU with approval extended until 2032. Also registered for use in wood preservatives under the EU biocidal products directive (2008). Rizobacter launched the product as part of Maxim Evolution (with fludioxonil and metalaxyl-M) in Argentina in 2013. Syngenta introduced Mertect 340-F in 2015 for protection against Sudden Death Syndrome in soybeans. | | | | | |

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| **Thiacloprid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 150 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Biscaya, Calypso, Alanto) | None | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 20-60 |
| **Main Crops** | **Main Pests** | | |
| Rape, F&V, Maize, Pome fruit, Rice | A wide range of insects | | |
| **Main Mixture Partners :** imidacloprid, isotianil, spirotetramat | | | | | |
| **Recent History:**  Developed as BAY YRC2894. The product is active against sucking and chewing pests with applications in various crops. Pome and stone fruit is a particular area of focus for the product, whilst a lower application rate than imidacloprid for the control of Colorado beetle on potato is also seen as a benefit. First registered in Brazil, Hungary, Israel, Switzerland and some East European countries in 2000, with use now extending to a number of country markets, including Japan, where it is sold by Kumiai, the UK, Germany, France, Canada and the USA. Aeris, a cotton seed treatment in a mixture with imidacloprid, was introduced in the USA in 2007. Other introductions in recent years include with isotianil as Routine in Korea in 2010; with spirotetramat as Movento Smart in Chile in 2011; and as Calypso in Portugal for use on fruit in 2012. Has achieved Annex 1 approval in the EU; however, usage on bee sensitive crops in the EU has been suspended. Introduced by Lanxess in 2006 for use as a wood preservative for the control of termites, wood-boring beetles and other insects. In 2016 Bayer’s Calypso gained an approval extension in Italy for use on pears. | | | | | |

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| **Thiamethoxam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Nicotinamide | 1,060 | 1999 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Actara, Cruiser) | Tagros, Bharat Rasayan, Punjab Chemicals | | |
| **Application** | **Timing:** | Seed treatment, Soil, foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Soybean | Coleoptera, Soybean aphid, Stink bug | | |
| Maize | Corn rootworm, Cutworm, Flea beetle, Seedcorn maggot, Wireworm | | |
| F&V, Sugarcane, Cereals, Cotton, Rice, Rape, Potato | A wide range of insects | | |
| **Main Mixture Partners :**  cypermethrin, azoxystrobin, difenoconazole, metalaxyl-m, fludioxonil, chlorantraniliprole, abamectin, lambda-cyhalothrin, tefluthrin, sulfoxaflor, sedaxane | | | | | |
| **Recent History:**  The largest selling neonicotinoid insecticide, finding significant foliar (Actara) and seed treatment (Cruiser) uses. Utilised in many mixtures in seed treatments, primarily as a component of Syngenta’s CruiserMaxx range. Thiamethoxam is also being combined with Avicta and Maxim Quattro as Avicta Complete Corn for use on SmartStax maize. Gained biocidal approval as a non-crop insecticide in the EU in 2013, and was launched in the USA in combination with lambda-cyhalothrin as Tandem for residential, commercial and turf uses. EU approval has been extended to the end of April 2018, although usage on bee sensitive crops in the region has been suspended. Usage restrictions were also put in place in Brazil in 2015 due to concerns over bee health, with the product prohibited from being applied within 300 m. of flowering cotton fields. In 2014 Syngenta launched Cruiser Vibrance Quattro (difenoconazole, metalaxyl-M, sedaxane, fludioxonil and thiamethoxam) in Western Canada for the control of various diseases and insects on cereals. Syngenta launched its Visivio canola seed treatment in Canada, a mixture with sulfoxaflor, difenoconazole, metalaxyl-M, fludioxanil and sedaxane in 2016. | | | | | |

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| **Thiazopyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | <10 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Visor) | None | | |
| **Application** | **Timing:** | Pre-emergence | **Rate – (g/ha):** 15-2000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Nuts | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pyridine herbicide for pre-emergence control of grass and broadleaved weeds in fruit, citrus, vine and nut crops. Potential exists for introduction on cotton and peanuts. A niche product acquired by Rohm & Hass from Monsanto, and now part of the Dow portfolio. Not re-registered in the EU and left that market in July 2003. | | | | | |

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| **Thidiazuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 60 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Dropp) | Chinese Companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cotton | Defoliation | | |
| **Main Mixture Partners :** diuron | | | | | |
| **Recent History:**  Cotton defoliant active via leaf abscission at the petiole/stem junction causing leaf fall while the foliage is still green. Avoids the brittleness caused by some desiccants, thus reducing leaf shatter. Maintains a steady sales performance, although is subject to generic competition. Has been refused re-registration in the EU. In 2005 the US EPA issued a re-registration eligibility decision (RED), concluding that risk mitigation measures were required for approval. Achieved approval for use in China in 2015. | | | | | |

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| **Thiencarbazone methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Other ALS - Triazolone | 120 | 2009 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Adengo, Corvus, Capreno) |  | | |
| **Application** | **Timing:** | Pre- and early post-emergence | **Rate – (g/ha):** 7.5-15 |
| **Main Crops** | **Main Pests** | | |
| Maize, Cereals | Grass & broadleaved weeds | | |
| **Main Mixture Partners:** isoxaflutole, tembotrione, pyrasulfotole, bromoxynil, foramsulfuron, halosulfuron-methyl, tribenuron-methyl | | | | | |
| **Recent History:**  Active through inhibition of acetolactate synthase. Used on maize in combination with isoxaflutole and the proprietary herbicidal safener cyprosulfamide. The product received its first approval in 2008 in Romania. US introduction was achieved in 2009 as Corvus. Has also received approval in the EU, extending until the end of June 2024. Launched as Agendo in Argentina in 2010, the first thiencarbazone-methyl based product to receive registration in South America. Introduced in a mixture with tembotrione as Capreno for use on corn in the USA in 2011. Combined with Thumper (bromoxynil) as Thumper Total in Canada in 2010, aimed at post-emergence grass and broadleaf weed control. Other introductions in the USA include with pyrasulfotole, bromoxynil and mefenapyr for spring, durum and winter wheat as Huskie Complete; with foramsulfuron and halosulfuron as Tribute Total for turf; and with dicamba and iodosulfuron-methyl as Celcius for turf. In 2013 Bayer launched Percutor, a mixture with iodosulfuron-methyl, in Argentina for use on soybeans, maize and fallow. Monsoon Active (thiencarbazone-methyl, foramsulfuron and cyprosulfamide) was launched in Portugal and Spain for use on maize in 2015. In 2017 it was approved for use on maize in China. | | | | | |

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| **Thifensulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 115 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Harmony, Pinnacle) | None | | |
| **Application** | **Timing:** | Post emergence | **Rate – (g/ha):** 4-20 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Soybean, Maize | Broadleaved weeds | | |
| **Main Mixture Partners :**  metsulfuron-methyl, tribenuron-methyl, rimsulfuron, terbuthylazine, clodinafop, chlorsulfuron, thiencarbazone, MCPA, fluroxypyr | | | | | |
| **Recent History:**  Sulfonylurea herbicide of short persistence offering control of a wide spectrum of broadleaved weeds. Marketed as Harmony for use on cereals, Pinnacle for soybeans and also used in mixtures on maize. Sales on soybeans declined due to the impact of herbicide tolerant varieties and are now down from peak levels; however sales on cereals have benefited from usage in mixture formulations. Has achieved re-registration in the EU. The product has been introduced in the US market by a number of companies, including Rotam as Volta in 2007 for pre-plant burndown and post-harvest applications on wheat, grains, soybeans and corn; Cheminova (now part of FMC) as Harass in 2008 for use on cereals and with rimsulfuron as Crusher in 2013 for pre-plant and pre-emergence use on maize and pre-plant use on soybeans, cotton and peanuts; Arysta in 2010 in a mixture with fluroxypyr and tribenuron-methyl as Supremacy for use on cereals; DuPont in mixtures with rimsulfuron as LeadOff for use on maize, soybeans and cotton in 2011 and as Basis Blend in 2013. In 2015 DuPont received registrations in Canada for Predicade (thiencarbazone, tribenuron, thifensulfuron, fluroxypyr and MCPA) and Travallas (metsulfuron-methyl, thifensulfuron-methyl and fluroxypyr) for use on cereals. In 2017 DuPont divested thifensulfuron-methyl to FMC as part of the regulatory conditions required for the merger approval between Dow and DuPont. | | | | | |

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| **Thifluzamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SDHI | <30 | 1997 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nissan Chemical (Greatam, Pulsor) | Dow | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 125-250 |
| **Main Crops** | **Main Pests** | | |
| Rice | Sheath blight | | |
| Potato | Black scurf | | |  | |
| **Main Mixture Partners :** imidacloprid, carpropamid | | | | | |
| **Recent History:**  Specific fungicide for the control of *Rhizoctonia solani* (sheath blight) in rice, and also black scurf of potatoes. The product has nursery box activity, with a mixture of imidacloprid and carpropamid now commercialised. Major markets are Japan, Korea and Latin American countries. Nissan acquired the product from Dow in 2010, although Dow retained certain formulations for rice nursery box applications in Japan. Insecticides India introduced Pulsor into the Indian rice market through an agreement with Nissan Chemical in 2012. | | | | | |

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| **Thiobencarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate | <30 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Kumiai (Saturn) | None | | |
| **Application** | **Timing:** | Pre-emergence, Post-emergence | **Rate – (g/ha):** 2000-7500 |
| **Main Crops** | **Main Pests** | | |
| Rice | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** linuron, bensulfuron, mefenacet, bromobutide | | | | | |
| **Recent History:**  Broad-spectrum rice herbicide initially used in the one-shot rice herbicides Wolf-Ace (with bensulfuron and mefenacet) and Power Wolf (with bromobutide, bensulfuron and mefenacet) in Japan, also used in mixtures with a range of other rice herbicides. Marketed under license by Valent in the USA, with a granular formulation introduced in 2001 and a combination with imazosulfuron as League introduced in 2012. Kumiai withdrew the product from the Japanese rice market in 2007 in favour of alternative products. Not registered in the EU. | | | | | |

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| **Thiocyclam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Natural Product | <10 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Arysta / Nippon Kayaku (Evisect) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 150-500 |
| **Main Crops** | **Main Pests** | | |
| F&V | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Analogue of the natural toxin nereistoxin with wide ranging insecticidal activity. Passed to Syngenta following the sale of its stake in SDS Biotech. Of limited commercial significance but acquired by Arysta and Nippon Kayaku (who have manufactured the product under licence since 1984) from Syngenta in 2002. The main markets are vegetables and ornamentals in Latin America, Japan, the Middle East and Asia. Not registered in the EU. | | | | | |

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| **Thiodicarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | 85 | 1977 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Larvin) | Chinese companies | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 140-1000 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Cutworm, Corn earworm, Fall armyworm, Soybean looper | | |
| Cotton | Bollworm complex, Lepidoptera | | |
| Maize | Corn Rootworm, Cutworm, Armyworm, Flea Beetle, Aphid | | |
| Plantation crops, F&V | A wide range of insects | | |
| **Main Mixture Partners :** imidacloprid | | | | | |
| **Recent History:**  Broad-spectrum carbamate insecticide, an analogue of methomyl. Has not been re-registered in the EU. Bayer launched the maize seed treatment CropStar, a combination with imidacloprid, in Argentina in 2006 and Brazil in 2008. In 2017 Nufarm launched a seed treatment platform in Brazil based on Sadler 350 (thiodicarb) among other products. | | | | | |

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| **Thiophanate-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Benzimidazole | 200 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Topsin) | UPL, Rallis, FarmHannong, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-1800 |
| **Main Crops** | **Main Pests** | | |
| F&V, Cereals, Plantation crops, Peanuts, Pome fruit, Rice | A wide range of diseases | | |
| Soybean | Brown spot, Septoria leaf blight, Leaf blight, Pod and Stem blight, Target spot | | |  | |
| **Main Mixture Partners :** mancozeb, vinclozolin, procymidone, epoxiconazole, thiram, pyraclostrobin, fipronil, fluazinam, pyraclostrobin | | | | | |
| **Recent History:**  Broad-spectrum fungicide with applications in a wide variety of crops. A precursor for carbendazim, and suffers from similar resistance problems. Has been the subject of some regulatory concern; however it has been re-registered in the EU, with approval for the product extended to the end of October 2018. Certis Spain launched the product as Cerobin in Spain in 2008 for powdery mildew control on fruit and *Fusarium* and rust on cereals. In 2009 BASF launched the seed treatment Sandak Top (pyraclostrobin, thiophanate methyl and fipronil) for use on soybeans, maize, cotton and cereals in Brazil. In 2010 Iharabras launched Certeza (thiophanate-methyl and fluazinam) for use on soybeans and kidney beans in Brazil. BASF supply the Argentine seed company Sursem with the product in a mixture with pyraclostrobin as Acronis for treatment of Sursem soybean seed. In 2014 Cheminova (now part of FMC) launched Cerobin for use on a range of crops in the US and gained approval in Spain for use in oak plantations to eliminate canker. In 2017 Ihara launched Approve (thiophanate-methyl, fluazinam) for use on soybean, cotton, maize and beans. | | | | | |

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| **Thiram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite -Dithiocarbamate | 90 | 1948 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Tripamol, Thionasan) | Taminco, FarmHannong | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals | *Fusarium*, Seed rot, Root rot, *Septoria*, Loose smut | | |
| Soybean | Pod and Stem blight | | |
| F&V, Pome fruit, Maize | A wide range of diseases | | |
| **Main Mixture Partners :** carboxin, carbendazim, iprodione, benomyl, thiophanate-methyl, triticonazole, chlorothalonil | | | | | |
| **Recent History:**  Protective contact dithiocarbamate fungicide offering control of a range of foliar diseases, including *Venturia, Alternaria*,and *Botrytis*. Also used in mixtures as a seed treatment for the control of soil borne diseases, particularly *Fusarium*. Used on a large area of Brazilian soybeans for Asian rust control as a seed treatment, although not a major product in value terms. Has gained re-approval in the EU, extended until the end of April 2018. In 2005 BASF received approval for Gemini, a combination seed treatment with triticonazole, in Canada. In 2009 Taminco appointed Chemtura (now Arysta LifeScience) as the exclusive distributor of its Granuflo product in the USA. Kumiai launched the product in combination with chlorothalonil as Riken DacoGreen in 2013. In 2014 Certis Europe extended its deal to distribute Vitavax Flo NF (carboxin and thiram) and Thiraflo (thiram) to Italy and the UK respectively. | | | | | |

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| **Tiadinil** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Carboxamide | <30 | 2003 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku (V-Get) | None | | |
| **Application** | **Timing:** | Seed treatment (granule) for nursery box application | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice Blast and some bacterial diseases | | |
| **Main Mixture Partners :** chlorantraniliprole, clothianidin, benfuracarb | | | | | |
| **Recent History:**  Introduced in Japan and registered in South Korea in 2003. Active through induction of the plant’s natural defence mechanisms. As the product is not as active by foliar application, the market in China and Vietnam is of limited potential. The compound complements Nihon Nohyaku’s fenoxanil, which is more active on panicle blast. Nursery box applications in combination with plant hopper and leaf roller control products were introduced in 2004, including combinations with a number of insecticides. In 2012 Nihon Nohyaku expanded the V-Get range with chlorantraniliprole mixture products. | | | | | |

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| **Tolclofos-methyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Rizolex) | Chinese companies | | |
| **Application** | **Timing:** | Seed treatment, Soil applied | **Rate – (g/ha):** 500-1000 |
| **Main Crops** | **Main Pests** | | |
| Potato | Black scurf | | |
| F&V, Cereals | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus fungicide which is used for both soil and seed treatment in a wide range of crops. Offers control of *Rhizoctonia, Corticium, Sclerotium*,and *Typhula* spp. Received full Annex 1 re-registration in the EU with approval extended until the end of April 2018. In 2012 Sumitomo gained registration for the product as Rizolex in the Netherlands for use on flowers, with Rizolex gaining US registration in 2013 for use on maize, soybean, cotton, sugarbeet and sorghum. | | | | | |

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| **Tolfenpyrad** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Other | <30 | 2002 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nihon Nohyaku  (Hachi hachi) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 75-200 |
| **Main Crops** | **Main Pests** | | |
| F&V, Ornamentals | Diamondback moth, common cabbage moth, aphids, thrips | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Active through the inhibition of egg laying, reduced egg survival, and inhibition of feeding also observed in other insect species. Originally developed by Mitsubishi Chemical and now part of Nihon Nohyaku. Achieved Japanese registration in 2002 in conjunction with OAT Agrio for use on vegetables and ornamentals. Flowable formulation introduced for use on fruit trees in 2003. Gained approval from the US EPA in 2010 for use on greenhouse ornamentals and was registered for food uses in 2014. Engage Agro market the product in Canada. | | | | | |

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| **Tolprocarb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Carbamate | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Mitsui Chemicals Agro (Sunblas) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 900-1200 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice Blast | | |
| **Main Mixture Partners:** dinotefuran, simeconazole, chlorantraniliprole | | | | | |
| **Recent History:**  Rice blast fungicide active through inhibition of melanin biosynthesis in the cell wall, although via a different target site (polyketide synthase) to existing melanin biosynthesis inhibitors. Mitsui Chemicals Agro introduced the product in Japan in 2015 as the single formulation Sunblas G as well as in the insecticide/fungicide combination products Guts-Star G (with dinotefuran and simeconazole) and Suntriple G (with dinotefuran and chlorantraniliprole). The company has also gained registration in Japan for the product in a mixture with dinotefuran as Sunblas Starkle Box G. Mitsui made two tolprocarb based product introductions in Japan in 2016 for rice nursery box treatment, Hyperkick G (dinotefuran, tolprocarb), and Tripplekick G (tolprocarb, simeconazole, cyantraniliprole). | | | | | |

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| **Tolpyralate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD | - | 2017 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Ishihara (Shieldex) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 30-50 |
| **Crops** | **Main Pests** | | |
| Maize | Grass and Broadleaf weeds Palmer amaranth/ tall water hemp (Amaranthus spp), giant ragweed (Ambrosia trifida) and giant foxtail (Setaria faberi) | | |
| **Recent History:**  Under development for use in major markets worldwide. Regulatory approvals were proposed in Canada in September 2017, and in the US in May 2017, both for use on maize, sweetcorn and popcorn. In late 2017 Summit Agro USA launched Shieldex 400 SC (topyralate) for the control of broadleaved weeds such as Palmer amaranth (*Amaranthus palmeri*), giant ragweed (*Ambrosia trifida*) and giant foxtail (*Setaria faberi*). Shieldex 400 SC will be exclusively distributed in the US by Helena Chemical and Tenkoz. | | | | | |

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| **Tolylfluanid** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Other | <10 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Euparen M) | None | | |
| **Application** | **Timing:** | Foliar, Seed Treatment | **Rate – (g/ha):** 1500-7000 |
| **Main Crops** | **Main Pests** | | |
| Vine | *Botrytis* | | |
| F&V | A wide range of diseases | | |
| **Main Mixture Partners:** tebuconazole | | | | | |
| **Recent History:**  Broad-spectrum fungicide used primarily for the control of scab (pome fruit) and *Botrytis* (strawberries and vines). Secondary activity against spider mites and powdery mildew. Used as a seed dressing for cotton and vegetables for damping-off diseases. Banned in Germany and the UK following concerns over contamination of drinking water, the product is no longer approved in the EU. Due to a toxic metabolite, Bayer made the decision in 2008 to wind down its tolylfluanid business worldwide. Lanxess still hold a registration for the product as a biocide in the EU. | | | | | |

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| **Topramezone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | HPPD Inhibitor | 90 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Clio, Impact, Armezon) |  | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 12.5-25 |
| **Main Crops** | **Main Pests** | | |
| Maize | Broadleaf weeds, grass | | |
| **Main Mixture Partners:** atrazine, dimethenamid, bromoxynil | | | | | |
| **Recent History:**  Hydroxypyrazole herbicide active through inhibition of 4-hydroxyphenyl pyruvate dioxygenase (HPPD) in the carotenoid biosynthesis pathway. Offers control of grass weeds and some broadleaf weeds at high rates of application. Licensed to Amvac in the USA, with the company introducing Impact into the country following registration in 2005. Amvac’s topramezone is now part of Monsanto’s Roundup Ready Plus platform, with this agreement extended until the end of August 2017. Also received approval in Canada and Germany in 2005. Introduced in Europe and the USA in 2006 and in Argentina and Mexico in 2007. BASF received regulatory approval in Canada in 2009 for the application of Impact as a tank mix with glyphosate for use on glyphosate tolerant corn. Licensed to Nippon Soda in Japan. BASF launched Armezon in the USA in 2012 for use on maize and turf, and in Canada for use on maize. Armezon is now part of Monsanto’s Roundup Weathermax program in Canada. Topramezone has been proposed for approval in Australia in 2017. | | | | | |

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| **Tralkoxydim** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Cyclohexanedione | <30 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Grasp, Achieve) | Adama | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100-300 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Grasses | | |
| **Main Mixture Partners :** bromoxynil, MCPA | | | | | |
| **Recent History:**  Post-emergence grass-weed herbicide for use on cereals. Sales have been impacted by increasing competition from more recent products (clodinafop and fenoxaprop). Adama launched the first generic version of tralkoxydim in the UK in July 2006. Re-registration in the EU has been achieved until April 2019. | | | | | |

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| **Tralomethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | <10 | 1986 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Scout) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 5-20 |
| **Main Crops** | **Main Pests** | | |
| F&V, Potato | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Brominated analogue of deltamethrin developed by Roussel as a deltamethrin substitute for the US where sales were precluded by the NRDC licence, although this restriction has since passed. Tralomethrin has always been of limited significance in the pyrethroids sector. Not re-registered in the EU and left that market in July 2003, Bayer having decided to discontinue manufacture of the product. Bayer voluntarily cancelled product registrations and active ingredient approval for the product in the USA in 2010. | | | | | |

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| **Triadimefon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 60 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Bayleton) | Chinese Companies | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 70-300 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize, Plantation crops, F&V, Cotton | A wide range of diseases. | | |
| **Main Mixture Partners :** isofenphos, carbendazim, carbofuran, tebuconazole, triadimenol, propineb, cymoxanil, flutriafol | | | | | |
| **Recent History:**  First generation triazole fungicide which was at one time a leading cereal product but is now in decline due to resistance problems and has been superseded by new introductions. Some labels have not been supported due to the cost of re-registration. Not re-registered in the EU and registration in the USA was cancelled by the EPA at the request of Bayer in 2008. By far the major market for the product is now in China, mostly on cereals, but also on a wide range of other crops. | | | | | |

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| **Triadimenol** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | 80 | 1980 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Bayfidan, Baytan) | Adama, Chinese Companies | | |
| **Application** | **Timing:** | Foliar, Seed treatment | **Rate – (g/ha):** 50-125 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Plantation crops, F&V, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** spiroxamine, tebuconazole, folpet, triadimefon, propineb, cymoxanil | | | | | |
| **Recent History:**  At one time a leading cereal fungicide, now overtaken by tebuconazole and other new products and of less significance in the cereal fungicide sector, with sales down from peak levels. Also used in many mixtures as a seed treatment for control of *Rhyncosporium* and rusts. Also used on coffee, fruit, vegetables, vines, tobacco and bananas. Achieved Annex 1 registration in the EU, with approval until August 2019. The rights to Baytan in the UK were divested to Adama and the rights to Bayfidan in Germany to Stähler following the acquisition of Aventis. Currently under review for use in the USA. | | | | | |

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| **Triafamone** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS Other (Sulfonanilide) | <10 | 2015 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Council) |  | | |
| **Application** | **Timing:** | Pre- and post-emergence | **Rate – (g/ha):** 25-50 |
| **Crops** | **Main Pests** | | |
| Rice | Grasses, Sedges, Broadleaf weeds | | |
| **Main Mixture Partners:** tefuryltrione | | | | | |
| **Recent History:**  Selective herbicidal substance (developed as AE 1887196) which can be used in direct seeded or transplanted rice from seeding or transplanting to late post-emergence in spray or granular formulations. The product acts by inhibition of the enzyme acetolactate synthase (ALS inhibitor) and is used to control a range of weeds.  Council, which contains triafamone in combination with tefuryltrione, was approved in South Korea in 2014, and subsequently launched in 2015. Currently under development in other major rice growing countries. | | | | | |

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| **Triallate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Carbamate - Thiocarbamate | <30 | 1960 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Avadex, Far-Go) | None | | |
| **Application** | **Timing:** | Pre-plant incorporated | **Rate – (g/ha):** 1200-2500 |
| **Main Crops** | **Main Pests** | | |
| Cereals, F&V | Grasses | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Pre-emergence herbicide for wild oat and annual grass control in cereals, particularly important for the pre-emergence control of resistant blackgrass, also with minor use on sugarbeet and rape. Has received Annex 1 approval in the EU. Monsanto decided not to support the product and closed its only production plant. In 2004 Gowan acquired the business and opened a new plant, as well as supporting the product through re-registration in the EU. It has also been granted the first NAFTA label to be recognised in the USA and Canada, meaning the product can move freely across the border without the need for re-labelling. | | | | | |

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| **Triasulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 35 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Amber, Logran) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 5-25 |
| **Main Crops** | **Main Pests** | | |
| Cereals | Broadleaved weeds | | |
| **Main Mixture Partners :** dicamba, chlorotoluron | | | | | |
| **Recent History:**  Sulfonylurea herbicide for broadleaved weed control in cereals, mainly used in mixtures. Of limited commercial significance in a very competitive market. It has not been re-registered in the EU. | | | | | |

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| **Triazamate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Others | <10 | 1994 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Aphistar) | None | | |
| **Application** | **Timing:** | Foliar, Soil applied | **Rate – (g/ha):** 35-280 |
| **Main Crops** | **Main Pests** | | |
| F&V | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Specific systemic aphicide with a variety of target crops developed by Rohm & Haas (now Dow) and licensed to BASF who sell the product as Aztec for markets outside the US. Not registered in the EU. | | | | | |

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| **Triaziflam** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Triazine | <10 | 2006 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Idemitsu Kosan (Idetop) | None | | |
| **Application** | **Timing:** | Pre- and early post-emergence | **Rate – (g/ha):** 250-1000 |
| **Main Crops** | **Main Pests** | | |
| Rice | Broadleaved weeds | | |
| **Main Mixture Partners:** | | | | | |
| **Recent History:**  Reported to have multiple sites of action, including PET inhibitory activity, mitotic disruption by inhibiting microtubule formation and inhibition of cellulose synthesis. Introduced in 2006 in Japan as Idetop. | | | | | |

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| **Triazophos** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 70 | 1970 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Hostathion) | Sudarshan, Chinese Companies, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 320-2000 |
| **Main Crops** | **Main Pests** | | |
| Rice, Cotton, Cereals | Leatherjackets, Aphids, Beetles, Borers, Leafhoppers, Leaf minors, Nematodes, Mites | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Broad-spectrum organophosphorus insecticide used mainly for aphid control. Also has miticidal and nematicidal activity. The product is now mature and was not re-registered in the EU. In 2013 Brazilian authorities cancelled registration for Deltaphos (with deltamethrin) and Hostathion at the request of Bayer. Use in China is to be banned from the end of 2016. In India, the import manufacture of folmulation of triazophos will be banned by 2019 with a complete ban effective from the end of 2020. | | | | | |

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| **Tribenuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 125 | 1985 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Granstar, Express, Pointer) | Chinese Companies | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 8-13 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sunflower | Broadleaved weeds | | |
| **Main Mixture Partners :**  metribuzin, thifensulfuron, clodinafop, cinidon-ethyl, dichlorprop-p, MCPA, metsulfuron, fluroxypyr, flumioxazin, thiencarbazone, MCPA | | | | | |
| **Recent History:**  Short persistence selective sulfonylurea herbicide for the control of broadleaved weeds in cereals, mainly used in combination with other sulfonylureas and with metribuzin. The product has received full Annex 1 re-registration in the EU; however sales in the region have been affected by competitive introductions with China now the most significant country market. In 2007 Pioneer introduced a sunflower hybrid in the USA containing the DuPont ExpressSun trait which provides tolerance to tribenuron-methyl. In 2011 Arysta introduced the product in a mixture with fluroxypyr and thifensulfuron-methyl as Supremacy for use on cereals in the USA, and in a mixture with flucarbazone as Inferno Duo for use on wheat in Canada in 2013. In 2013 DuPont launched the product in a mixture with thifensulfuron-methyl as Panoflex in the USA for pre-plant burndown control of winter annuals, broadleaf weeds and volunteer glyphosate-resistant canola in wheat, barley and soybeans. In 2014 DuPont gained registration for Afforia (a mixture of tribenuron, thifensulfuron and flumioxazin) in the USA for use in soybeans and other field crops. This was followed in 2015 by the US launch of Predicade (thiencarbazone, tribenuron, thifensulfuron, fluroxypyr and MCPA) for use on spring and durum wheat. Tribenuron-methyl will be divested to FMC as a result of the Dow-DuPont merger. | | | | | |

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| **Tributyl phosphorotrithioate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <30 | 1965 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Amvac (Def 6, Folex) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 1100-2500 |
| **Main Crops** | **Main Pests** | | |
| Cotton | n.a. | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Cotton defoliant causing leaf drop whilst foliage is green, also known as tribufos and often used in combination with other defoliants. An organophosphorus product but deemed acceptable for re-registration in the USA. Acquired by Amvac from Bayer following the acquisition of Aventis. Amvac began operations at its tribufos production unit in Axis, Alabama in 2012. | | | | | |

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| **Trichlorfon** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Organophosphate | 45 | 1957 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Dipterex) | Cequisa, Adama, Chinese Companies, FarmHannong | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 400-1400 |
| **Main Crops** | **Main Pests** | | |
| Rice, Cereals, F&V, Cotton | A wide range of insects / mites and nematodes | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Commodity organophosphorus insecticide especially active against fly species, surface feeding & mining caterpillars, and bug species. An ageing product subject to generic competition and regulatory scrutiny, although also finds sales in animal health. Acquired by UPL from Bayer in 2006, although Bayer has retained the home and garden uses. Not re-registered in the EU with the product being phased out by the end of 2008. Generally accepted in the USA where it is used mainly in non-crop situations; however some home and golf course applications have been cancelled. Also banned in Brazil in 2010. | | | | | |

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| **Triclopyr** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Pyridine | 150 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Garlon) | Chinese Companies, Gharda, Adama, Meghmani, Punjab Chemicals | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 240-8000 |
| **Main Crops** | **Main Pests** | | |
| Plantation crops, Cereals, Rice | Broadleaved weeds | | |
| **Main Mixture Partners :** aminopyralid | | | | | |
| **Recent History:**  Pyridine herbicide for the control of broadleaved and woody weeds in grassland and non-crop situations, in orchards and for burn down pre-planting in a number of crops. Re-registration in the EU has been approved and extended to April 2018, under certain use restrictions. SePRO has developed the product for the control of woody, broadleaf and aquatic weeds in ponds, lakes and marshes as Renovate. In 2003 Nufarm introduced Tahoe for brush weed control in non-crop areas. Adama gained a generic approval in the USA in 2005. | | | | | |

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| **Tricyclazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other azoles | 115 | 1975 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Beam) | Kumiai, Indofil, Tagros, Chinese Companies, FarmHannong, Heranba, Meghmani | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 150-400 |
| **Main Crops** | **Main Pests** | | |
| Rice | Rice blast | | |
| **Main Mixture Partners :** fipronil, kasugamycin, propiconazole, tebuconazole | | | | | |
| **Recent History:**  Rice blast fungicide discovered by Elanco. Manufactured by Dow and distributed by Kumiai throughout East Asia under licence. Provides season long control of rice blast and is used in combination with fipronil as Beam/Prince for the nursery box market. Sales of the product have been impacted by competition from recent blasticide introductions and from generic competition. Arysta launched the product in a mixture with kasugamycin as Kasai-S in Vietnam in 2012 for use on rice, with manufacturing for the product taking place at its formulation plant in Vietnam. In 2015 Syngenta launched Filia, a mixture with propiconazole, for the control of rice neck blast in Malaysia. EU maximum residual limits of tricyclazone were reduced in 2017 to a level that effectively bans the import of rice treated with the substance. Cambodia, a supplier of rice to the EU has banned the import of tricyclazole in response. | | | | | |

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| **Tridemorph** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Morpholine | <30 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Calixin) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 375-570 |
| **Main Crops** | **Main Pests** | | |
| F&V, Plantation crops | Disease | | |
| **Main Mixture Partners :** epoxiconazole | | | | | |
| **Recent History:**  Early morpholine product for powdery mildew on vegetables. Now largely superseded by more recent morpholines and powdery mildew control products, however still finds sales in mixtures, especially in eastern Europe. Not re-registered in the EU. The trade and use of tridemorph is banned in India from 1st January 2018. | | | | | |

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| **Trifloxystrobin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Strobilurin | 640 | 2000 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Flint, Stratego) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 62.5-187.5 |
| **Main Crops** | **Main Pests** | | |
| Soybean | Asian Rust, Brown spot / Septoria leaf blight, Aerial Blight, Leaf blight, Powdery mildew | | |
| Cereals | Brown rust, Septoria leaf spot, Net blotch, Leaf blotch, Powdery mildew | | |
| F&V, Maize, Peanut, Rice, Turf, Ornamentals | A wide range of diseases | | |
| **Main Mixture Partners :**  cyproconazole, propiconazole, captan, cymoxanil, tebuconazole, prothioconazole, penflufen, fluopyram, trifloxystrobin | | | | | |
| **Recent History:**  Developed by Novartis and divested to Bayer on the formation of Syngenta in 2000. The product has particular strength against powdery mildew, *Septoria* and *Rhyncosporium* on cereals, particularly competitive in the early spray season. Has received Annex 1 approval in the EU, extended to the end of July 2018. Bayer has introduced mixtures with penflufen in the USA and Canada for canola as Prosper EverGol in 2012, and with fluopyram as Luna Sensation for use on nut, fruit and field crops. In 2015 Bayer extended the use of Nativo (trifloxystrobin and tebuconazole) for application on sugarcane in Brazil, the company’s first sugarcane fungicide. In 2016 Bayer launched Absolute Maxx (a mixture with tebuconazole) and Exteris Stressgard (also containing fluopyram) in the USA. Also in 2016 Bayer entered into an agreement with West Central Distribution regarding the introduction of a fungicidal soybean seed treatment combination, Redigo 480 + Trilex (prothioconazole and trifloxystrobin). | | | | | |

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| **Trifloxysulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS-Sulfonylurea | 50 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta  (Envoke, Krismat, Enfield) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cotton, Sugarcane | Broadleaf and Grass weeds | | |
| **Main Mixture Partners :** prometryn, ametryn | | | | | |
| **Recent History:**  Developed by Syngenta as CGA362622, first introduced in 2001 as Krismat in Brazil. The product has a broad window of application, particularly for control of grass weeds and offers good activity for the control of important sugarcane weeds *Brachiaria, Rottboellia* and *Euphorbia.* Registered in Colombia, throughout Latin America and in Australia in 2002. Registered in the US for use on cotton, sugarcane and tomatoes as Envoke in 2003 and almonds, tree fruit and citrus in 2005 and on turf as Monument in 2004. Monument received approval in Japan in 2003 for use on turf. In 2012 Syngenta launched a single-dose formulation of Monument for use on turf in the USA. In 2017 Syngenta’s Krismat WG (trifloxysulfuron, ametryn) product was divested to Amvac Mexico, as part of the demands set out by the Mexican authorities over the acquisition of Syngenta by ChemChina. | | | | | |

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| **Triflumizole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other Azole | <30 | 1987 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Nippon Soda (Trifmine) | None | | |
| **Application** | **Timing:** | Foliar,  Seed treatment | **Rate – (g/ha):** 300-3000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit, Vine, Rice | Scab, Rusts, Powdery mildew | | |
| **Main Mixture Partners :** cyflufenamid | | | | | |
| **Recent History:**  Azole fungicide with activity against scab and rust on pome fruit and powdery mildew on a range of fruit and vegetable crops. Also used as a rice seed treatment to control seed-borne diseases. Has received registration in the EU for use in greenhouses. Marketed by Arysta LifeScience as Procure in the USA for use on a range of fruit, nut and vegetable crops, as well as ornamentals. | | | | | |

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| **Triflumuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Benzoylurea | 55 | 1979 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Bayer (Certero, Alsystin) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-250 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Plantation crops, F&V, Maize, Sugarcane | Insects, Other Lepidoptera | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Benzoylurea insect growth regulator for use against biting insects (particularly caterpillars) in a wide range of crops. Has approval in the EU until March 2021. | | | | | |

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| **Trifluralin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | Dinitroaniline | 120 | 1964 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Treflan) | Nufarm, Adama, Bayer, Nortox, IPiCi, Budapest, Agro-San, Atanor, Sipcam, Phytorus | | |
| **Application** | **Timing:** | Pre-plant incorporated, Pre-emergence | **Rate – (g/ha):** 575-1100 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Cotton, F&V, Soybean, Rape, Sugarcane, Sunflower | Grasses | | |
| **Main Mixture Partners :** diflufenican | | | | | |
| **Recent History:**  Dinitroaniline herbicide for pre-emergence grass weed control in a wide range of crops. At one time a leading soybean herbicide in the USA but now superseded by more recent introductions and deflated by the uptake of herbicide tolerant varieties. Now of commodity status with a large number of generic manufacturers. In 2010 Adama’s trifluralin entered Monsanto Roundup Ready Plus program. Refused re-registration in the EU in 2010 and classified as a priority hazardous substance in 2013. In 2015 Gowan acquired Dow’s global dinitroaniline herbicide business. Gained Canadian re-approval in 2016. Trade and use is banned in India as of 1st January 2018. | | | | | |

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| **Triflusulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | 55 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| DuPont (Caribou, debut, Ultrafor) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 50 |
| **Main Crops** | **Main Pests** | | |
| Sugarbeet | Grasses, Broadleaved weeds | | |
| **Main Mixture Partners :** tribenuron | | | | | |
| **Recent History:**  The only sulfonylurea herbicide for use on sugarbeet. Provides post-emergence control of *Galium*, other broadleaved weeds, and grasses. Now introduced in most sugarbeet producing countries and maintains a steady share of a relatively stable market. The product has received re-registration in the EU with approval lasting until the end of 2019. In 2017 DuPont agreed to divest triflusulfuron-methyl to FMC as part of the closing conditions for the Dow-DuPont merger. | | | | | |

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| **Triforine** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Other | <10 | 1969 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Corporation (Saprol) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 200-300 |
| **Main Crops** | **Main Pests** | | |
| F&V | A wide range of diseases | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  At one time the centre of Shell’s fungicide portfolio, but now of less significance. Sumitomo Corporation acquired BASF’s global triforine business in 2005. Active by sterol biosynthesis inhibition against powdery mildew on a range of fruit and vegetable crops, rusts on cereals, and fruit and rot diseases of stone fruit. Also with usage on ornamentals and secondary activity suppressing mites. Has not been re-registered in the EU. | | | | | |

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| **Trinexapac-ethyl** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | 150 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Syngenta (Moddus, Pallisade) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 100-500 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Sugarcane | n.a. | | |
| **Main Mixture Partners :** ethephon | | | | | |
| **Recent History:**  Plant growth regulator to prevent lodging in cereals by inhibition of gibberellin biosynthesis. Also introduced for use on sugarcane, rice and grasses and as Palisade for use on pome fruit, citrus, onions, and alfalfa. Achieved full Annex 1 registration in the EU with approval extended until the end of April 2018. Syngenta gained US approval for the product as Palisade for use on cereals, seed grasses and sugarcane in 2012, and in 2014 Canadian approval for ryegrass seed as Parlay. | | | | | |

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| **Triticonazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | SBI - Triazole | <30 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Real, Premis,Charter) | None | | |
| **Application** | **Timing:** | Seed treatment | **Rate – (g/ha):** |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Brown rust, Powdery mildew, Yellow rust, Head smut, Common Bunt | | |
| **Main Mixture Partners :** thiram, chlorothalonil, triticonazole, metalaxyl, pyraclostrobin | | | | | |
| **Recent History:**  Triazole seed treatment fungicide claiming a long duration of action due to systemic uptake. Active against a range of cereal diseases, especially early season powdery mildew, *Fusarium*,and *Septoria* although the product has not made a major commercial impact. Has received full Annex 1 registration in the EU with approval extended until the end of April 2018. In 2002 Bayer divested the global seed treatment rights to BASF following the acquisition of Aventis, although BASF provide Bayer with the product for the turf and ornamental markets in the US and Canada. Also featured in several combination products, including with thiram as Charter PB in the US for cereals; with chlorothalonil for use on golf course turf; with metalaxyl as Charter F2 for use on wheat and barley in the USA; with pyraclostrobin and metalaxyl for seed treatment use on wheat and barley in the USA; and with pyraclostrobin and metalaxyl as Insure for use on cereals in Canada. In 2017 BASF launched Flite Flowable (triticonazole), a new turf fungicide, in Japan. | | | | | |

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| **Tritosulfuron** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Herbicide | | ALS - Sulfonylurea | <30 | 2004 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Bialthlon, Biathlon) | None | | |
| **Application** | **Timing:** | Post-emergence | **Rate – (g/ha):** 30-50 |
| **Main Crops** | **Main Pests** | | |
| Cereals, Maize | Broadleaved leaves | | |
| **Main Mixture Partners :** dicamba, florasulam | | | | | |
| **Recent History:**  First registered in Slovakia in 2003. Additional registrations have since been obtained in a number of other Eastern European countries, where it is mainly marketed in a combination with dicamba for use on cereals. Has achieved Annex 1 approval in the EU with approval valid until the end of November 2018. BASF’s Biathlon 4D (tritosulfuron and florasulam) was launched in Spain in 2016 for use on cereals. | | | | | |

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| **Uniconazole** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Other | | PGR | <30 | 1988 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Rakuichi, Sumishort, Sumagic) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 10-15 |
| **Main Crops** | **Main Pests** | | |
| F&V, Rice | n.a | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Triazole plant growth regulator principally used for lodging control in rice and also to reduce vegetative growth on ornamentals and trees. A minor product commercially. | | | | | |

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| **Validamycin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other - Antibiotic | 40 | 1972 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Validacin) | FarmHannong | | |
| **Application** | **Timing:** | Foliar,  Seed treatment, Soil drench | **Rate – (g/ha):** 90-120 |
| **Main Crops** | **Main Pests** | | |
| Rice | Sheath blight, damping-off | | |
| **Main Mixture Partners :** etofenprox, ferimzone, phthalide, silafluofen | | | | | |
| **Recent History:**  Antibiotic with fungistatic activity principally used to control sheath blight (*Rhizoctonia solani*) and damping-off disease in rice. A niche product in the Japanese rice sector, now also sold in India and South Korea. Not re-registered in the EU. Originally a Takeda product, now marketed by Sumitomo Chemical. | | | | | |

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| **Valifenalate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other- Dipeptide | <30 | 2010 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Belchim (Java, Yaba, Valis, Pegaso, Compass, Estocade) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 120-150 |
| **Crops** | **Main Pests** | | |
| Vine, Potato | Oomycete diseases, especially downy mildew. | | |
| **Main Mixture Partners:**  mancozeb, folpet | | | | | |
| **Recent History:**  Dipeptide fungicide for the control of oomycete diseases, developed to be complementary to benalaxyl and kiralaxyl. Offers preventative, curative and erradicant activity. First registration was achieved in 2007, and gained approval for registration to Annex 1 in the EU in 2014. In 2011 Isagro transferred the assets of the product to ISEM, a joint venture company between Isagro and Chemtura. In 2013 ISEM divested the rights and assets related to the product to Belchim, Belchim subsequently granting FMC an exclusive license to develop, register, manufacture and sell valifenalate in mixtures in Latin America, North America and select other countries. | | | | | |

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| **Vinclozolin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Dicarboxamide | <10 | 1976 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| BASF (Ronilan) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 375-1000 |
| **Main Crops** | **Main Pests** | | |
| Vine | *Botrytis* | | |
| F&V | A wide range of diseases | | |
| **Main Mixture Partners :** carbendazim, thiophanate-methyl | | | | | |
| **Recent History:**  At one time a major product for *Botrytis* control on vine and other fruit and vegetable crops, predominantly in Europe. Many uses in the USA have been lost to achieve compliance with FQPA regulations. In 2002 further labels on strawberries, stone fruits, cucumbers and bell peppers were revoked. Not re-registered in the EU and in the US a number of vegetable, fruit, and ornamental uses have been voluntarily withdrawn, although usages on vine and turf remain. | | | | | |

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| **Xylyl Methylcarbamate** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Carbamate | <10 | 1968 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Sumitomo Chemical (Macbal) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 600-800 |
| **Main Crops** | **Main Pests** | | |
| Rice | A wide range of insects | | |
| **Main Mixture Partners :** | | | | | |
| **Recent History:**  Carbamate insecticide used against plant hoppers and leafhoppers in Japan. Also known as xylylcarb. | | | | | |

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| **Zeta-Cypermethrin** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Insecticide | | Pyrethroid | 198 | 1992 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| FMC (Fury, Mustang) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 7.5-30 |
| **Main Crops** | **Main Pests** | | |
| Soybean, Cotton, Maize, Cereals, F&V | A wide range of insects | | |
| **Main Mixture Partners :** bifenthrin | | | | | |
| **Recent History:**  Partially resolved cypermethrin introduced by FMC in 1992 with similar activity to cypermethrin, but at lower application rates. Registered in a wide range of crop and non-crop situations. Has achieved re-registration in the EU with approval until the end of November 20121. BASF have access to the product through an agreement with FMC, marketing the product as Respect for use on a range of crops such as alfalfa, cotton, maize, soybeans, wheat and vegetables. Belchim launched the product in Italy in 2012 as Satel. In 2015 FMC’s Hero (zeta-cypermethrin and bifenthrin) was included on Monsanto’s Roundup Ready Plus Crop Management Solutions program. | | | | | |

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| **Zineb** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite - Dithiocarbamate | <30 | 1952 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Dow AgroSciences (Dithane Z-78) | UPL, Bayer, BASF, Isagro, Indofil | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 1625-2600 |
| **Main Crops** | **Main Pests** | | |
| Potato | Potato blight | | |
| F&V, Pome fruit, Rice | A wide range of Diseases | | |
| **Main Mixture Partners :** copper-oxychloride, metalaxyl | | | | | |
| **Recent History:**  Commodity contact dithiocarbamate fungicide principally used to control a variety of diseases on fruit and vegetables including downy mildew, blight, leaf spot, *Botrytis*, *Anthracnose*, and scab. A significant EBDC product used in many mixtures. EU re-registration has been refused and sales of the product in the region ceased in 2003. | | | | | |

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| **Ziram** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Multisite -Dithiocarbamate | <30 | 1949 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| UPL (Tricarbamix) | Taminco | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 3400-9000 |
| **Main Crops** | **Main Pests** | | |
| F&V, Pome fruit | A wide range of diseases | | |
| **Main Mixture Partners :** thiram, | | | | | |
| **Recent History:**  Commodity EBDC fungicide offering contact control of a broad range of diseases, particularly in fruit and vegetable crops. Annex 1 re-registration in the EU has been extended until the end of April 2018. Taminco produce and market the product in the USA. China revoked the manufacturing permit of the product in 2013. | | | | | |

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| **Zoxamide** | **Product Type:** | | **Class:** | **Sales ($m.):** | **Launch Date:** |
| Fungicide | | Other | <30 | 2001 |
| **Key Manufacturer / Brand:** | **Other Manufacturers:** | | | **Structure** | |
| Gowan (Zoxium, Gavel, Electis) | None | | |
| **Application** | **Timing:** | Foliar | **Rate – (g/ha):** 100-200 |
| **Main Crops** | **Main Pests** | | |
| Potato | Potato blight | | |
| Vine, F&V | A wide range of diseases | | |
| **Main Mixture Partners :** mancozeb, mandipropamid, chlorothalonil, dimethomorph | | | | | |
| **Recent History:**  Developed by Rohm & Haas as RH7281 and introduced by Dow in 2001 following their acquisition of the business. Has received Annex 1 approval in the EU, with approval extended until the end of January 2018. Introduced in the US, Canada, Mexico, Poland and the UK in 2001, classified as a reduced risk pesticide by the EPA. Gowan acquired the product from Dow in 2008 including trademarks registration data, patents and product inventories. Marketed principally in a 1:8 mixture with mancozeb for use against potato blight as Gavel, and Electis, the straight formulation. Introduced in France in 2003 in mixtures with mancozeb for use on vines, by Philagro as Roxam Combi and by Dow as Electis Pro, and as Aderio for use on potatoes. In 2013 Syngenta introduced Zominex, a co-pack with mandipropamid, for use on vine, tomatoes and potatoes. In 2015 Gowan received registration in the USA for Zing! (zoxamide and chlorothalonil) for use on potatoes, tomatoes, cucurbits and onions. Gowan’s Presidium (dimethomorph and zoxamide) was launched in the UK in 2016 for the control of potato blight. | | | | | |