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Non-Crop Pesticides
2016

Main Markets; Company Profiles and Product Portfolios; Disease, Insect and Weed Control; PGRs; Formulations

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Executive Summary

Chapter 1: Introduction

The scope of the report is defined and outlined, together with some background information.

The regulatory framework for non-crop pesticides, including plant protection products and biocides, is introduced.

Industry associations involved in the topic are listed and described.

Chapter 2: Non-crop pesticide markets

The global non-crop pesticides market is valued at around 11% of the total pesticide market, being worth over $6 billion (ex-manufacturer) in 2015.

Major market sectors for products are Home & Garden, Turf & Ornamentals, Pest Control Operations, Industrial Vegetation Management, Forestry, Public Heath, Aquatic. Another medium-sized sector is Timber Preservation. There are various sub-sectors such as Range & Pasture. Care must be taken because various organisations and publications use inconsistent segmentation and may cross those used in this report, *e.g.* Lawn & Garden.

The US is by far the largest geographic market sector.

There is increasing interest in the use of biopesticides in non-crop sectors.

Chapter 3: Company profiles and portfolios

Product portfolios and recent relevant activities of the leading companies in the various non-crop pesticides markets are reviewed.

Companies comprise the leading crop protection R&D intensive majors; some larger crop protection companies that have a particular focus on non-crop sector; the leading off-patent agrochemicals companies; and global distributors of branded consumer products.

Most active ingredients sold into non-crop markets are important in crop protection and primarily developed for such uses. However, a significant number are important non-crop pesticides in their own right.

There is increasing interest in biopesticides, particularly in sectors that are sensitive to actual and perceived issues of toxicology and environmental impact.

Chapter 4: Weed control

Each main sector of the non-crop pesticide market is considered with regard to the weed control objectives and targets, and the herbicides used.

The most widely used active ingredients are the world's biggest selling plant protection active ingredient the non-selective herbicide glyphosate, one of the original selective herbicides 2,4-D and one of the first sulfonylureas, metsulfuron-methyl.

New active ingredients include Bayer CropScience's indaziflam (*Specticle*) for broad-spectrum pre-emergence or early post-emergence control of grasses, sedges and BLW. Also BASF have introduced *Pylex* containing topramezone.

In the IVM sector selectivity is not an issue except in the important Range & Pasture segment where selectivity to grasses, used for hay and livestock grazing, is essential. IVM herbicides control annual and perennial BLW and grasses, sedges, brush (*e.g.* brambles and other woody shrubs) and tree saplings growing in warm and cool climates. Major herbicides are glyphosate and those from synthetic auxin, PSII inhibitor and ALS inhibitor modes of action.

In the Aquatic sector, problems may occur in and along the banks of rivers, canals, irrigation ditches, and ponds and lakes. Key features of invasive and other aquatic weeds include rapid growth, multiple reproductive methods, wide dispersal and survival, adaptation to many different environments and tenacity. Herbicides need to control floating, emergent and submerged weeds. Maintaining herbicidal concentrations in flowing water is a particular issue. Major herbicides include glyphosate, fluridone and diquat. Newer products contain bispyribac-sodium and flumioxazin.

In Turf & Ornamentals there must be absolutely no damage to turf grasses including domestic lawns, golf courses and other sports surfaces, and amenity landscapes; or to ornamentals, including flowers, bedding plants, shrubs and trees. Golf courses are especially important and various warm and cool-climate turf grasses are grown. BASF, Bayer and Syngenta have comprehensive product portfolios and services dedicated to the sector.

Forestry weed control is similar to IVM, although selectivity to trees is obviously essential and a variety of application methods are used. The main forestry herbicides include active ingredients with systemic action, effective on tougher perennial weeds and brush, such as glyphosate, imazapyr, sulfometuron-methyl, hexazinone and picloram.

Home & Garden weed control is similar to Turf & Ornamentals, but products are purchased and applied by amateurs. The range of active ingredients used is narrower with particular emphasis on controlling BLW in lawns, and on paths and drives or by spot application. Formulation and packaging innovations are used in branding and product differentiation.

Chapter 5: Disease control

The principal sector for fungicides is Turf & Ornamentals with smaller product ranges sold into Forestry, and Home & Garden.

The major diseases of cool and warm climate turf grasses for golf courses and lawns are listed and described. These include leaf spots, *e.g.* dollar spot; blights such as caused by *Pythium* and *Rhizoctonia* species; rusts and others. Disease of ornamentals are very extensive and some examples of common diseases of roses are noted.

The most popular fungicide active ingredients include chlorothalonil, iprodione and propiconazole. Many products are mixtures with the most popular mixture partners being azoxystrobin, fludioxonil, thiophanate-methyl and trifloxystrobin.

New fungicide active ingredients recently introduced into non-crop markets include BASF's fluxapyroxad; Bayer CropScience's fluopyram; ISK's isofetamid; Syngenta's benzovindiflupyr, oxathiapiprolin and penthiopyrad; and Valent USA Corporation's metconazole.

In future, biofungicides, with their good toxicological and environmental profiles, and 'green image', may become more important. Examples in current use are *Bacillus subtilis* (*Subtilex*) and *Trichoderma fertile* (*TrichoPlus*). New developments are listed.

Chapter 6: Control of insects and other pests

Many of the key pests targets in the Home & Garden PCO and Public Health sectors are the same. The problems posed by ants, termites, cockroaches and mosquitoes are discussed. In Turf, Ornamentals and Forestry, the major pest targets are more specific to the individual sectors and, therefore, these are discussed on a sector basis. A section on rodenticides is included.

Resistance to pesticides in an increasingly important issue. Repeated use of a single mode of action selects for resistant individuals in populations. With fewer new active ingredients with novel modes of action being commercialised and more stringent regulations resulting in the loss of active ingredients, the use of less broad spectrum products and IPM practices is being strongly advocated.

The most popular non-crop insecticides include abamectin, bifenthin, chlorpyrifos, deltamethrin, fiprinol, imidacloprid, lambda-cyhalothrin and permethrin. Many products are mixtures of two or more active ingredients. The most popular mixture partners are bifenthrin and cyfluthrin. Note that bifenthrin has been withdrawn from sale for non-crop use in the European Union. Pyrethroid insecticides are impregnated into mosquito nets for vector control.

A number of new active ingredients have been introduced into non-crop markets recently. These include: Adama's nematicide fluensulfone, BASF's afidopyropen (Meiji Seika Pharma) and broflanilide (Mitsui Chemical Agro); Bayer CropScience's fungicide/nematicide fluopyram; Nihon Nohyaku's buprofezin; and Dow AgroSciences's sulfoxaflor.

Bioinsecticides based on micro-organisms, nematodes or semiochemicals (*e.g.* pheromones) are becoming established in non-crop markets, especially where 'green' products attract a premium.

Chapter 7: Plant growth regulation

Plant growth regulators (PGRs) have been arguably more commercially successful in non-crop markets, especially in Turf & Ornamentals, than in mainstream agriculture.

The benefits from using PGRs include savings in the labour required and the costs involved in operations such as mowing or pruning; greater aesthetic appeal of treated plants; and an enhanced ability to withstand abiotic stresses such as drought and extremes of temperature.

Uniformity of application is essential to achieve an even effect on sports and amenity turf and treatment is usually by professional applicators. Some suppression of weeds may also occur.

PGRs may be applied to ornamental plants by a variety of methods including sprays, drenches or bulb soaks. Grower trials and sequential applications are often employed to ensure the correct dose and level of effect, given the great number of variants of species and varieties, as well as growing conditions.

Categories of ornamentals treated include bedding plants and plugs, bulbs, pot plants, woody plants and larger landscape ornamentals.

PGRs used in Turf & Ornamentals are mainly growth retardants. Most inhibit the biosynthesis of gibberellins at various points in the pathway, *e.g.* ancymidol, CCC, daminozide, paclobutrazol, trinexapac-ethyl. Some have alternative modes of action, *e.g.* ethephon, which decomposes to the plant hormone ethylene; and others such as mefluidide and dikegulac-sodium have poorly understood or unknown modes of action.

Chapter 8: Formulations for non-crop pesticides

A number of distinctive formulation types are used for non-crop pesticides (in addition to sprayable ones) which address important key customer values such as safety to all who might be exposed; particular features of pests and their habitats and locations; and ease and convenience of use.

Aerosols are a combination of formulation and specialized pack for spraying a fine mist or a forceful directed jet. Markets include household, garden, farm buildings, public or commercial premises and aircraft. They are often insecticides such as pyrethroids for rapid knockdown and kill, but suit any product where a small, localised application is needed.

Baits are solid formulations designed to attract and kill insects, molluscs or rodents. Palatability, texture, colour and shape can all effect successful control. Various types of bait are available to be deployed according to pest behaviour.

Dusts and powders are old types of formulation still used for the control of crawling insects and rodents; for use on wasps and ants nests; and to access cracks and cervices, and voids such as roof spaces or electrical service ducts where spraying would be difficult or undesirable. However, a modern innovation is Exosect's *Entostat* being used in stored products.

Fogs may be hot (thermal) or cold (mists). Both are generally used to treat large spaces, with inaccessible places. Thermal fogs are used for the fumigation of warehouses, grain stores, ships' holds and sewers. Cold fogs or mists have larger droplets so fall to the ground more quickly and are less penetrating.

Mosquito nets impregnated with insecticides (usually pyrethroids) are recommended by WHO as a key element in the fight against malaria as a vector control measure.

Smoke cartridges, pellets, tablets, tins and coils generate hot gases when ignited that condense on cooling to form a dense smoke. They give good coverage, but active ingredients must be stable to short periods of high temperatures (350–450 ^{o}C) and there is always the risk of fire.

Water soluble sachets make convenient doses of wettable powder formulations safer and easier to handle. When added to water the sachets burst and dissolve, dispersing the powder ready for spraying. PVA sachets must be compatible with the active ingredient and formulants, and sold in polythene or aluminium film packs to insure against accidental rupture.

Checking or preventing undesired growth of plants, except algae.

Active substances: substances or micro-organisms, including viruses, having general or specific action against harmful organisms or on plants, parts of plants or plant products.

Therefore, Regulation 1107/2009 also covers the regulation of many non-crop pesticides, *e.g.* when not used for hygiene purposes or as preservatives.

In the EU, biocides are covered by **Regulation 528/2012**, which came into force on 1 September 2013. This Regulation repealed and updated the earlier Biocidal Products Directive 98/8/EC. This was based on the Plant Protection Products Directive 91/414/EEC (now superseded by Regulation 1107/2009).

Under Regulation 528/2012, as previously, the approval of active substances takes place at EU level and the subsequent authorisation of particular products is by individual Member States. This authorisation can be extended to other Member States by mutual recognition. However, the new regulation also allows authorisation at the EU level. Details can be found on the website of the **European Chemicals Agency** (ECHA).

Under the Biocides Regulation products are classified into 22 types under four main groups. These are listed in Table 1.1.

Table 1.1. Categories of biocides recognised under the EU Biocidal Products Regulation 528/2012.

Disinfectants	Preservatives	Pest control	Other biocides
Human hygiene use (skin or scalp)	Use in storage of non food/cosmetics/medicines (*e.g.* pesticides)	Rodenticides	Antifouling products
Products not for direct application to humans or animal (*e.g.* use in buildings, materials, swimming pools)	Film preservatives (*e.g.* paints and other coatings)	Avicides	Embalming and taxidermist fluids
Veterinary hygiene use	Wood preservatives	Molluscicides, vermicides and other products to control invertebrates	
Food and feed equipment and area use	Fibre, leather, rubber and polymer preservatives	Piscicides	
Drinking water use	Use in construction material	Insecticides, acaricides and other products to control arthropods	
	Use in liquid coolants	Repellents and attractants	
	Slimicides	Control of other vertebrates	
	Use in cutting fluids		

Source: EU Biocidal Products Regulation 528/2012

Metsulfuron-methyl	*MSM Turf, 25 OD* *Negate* (+ rimsulfuron)	Turf, forestry, IVM	Selective post-emergence control of certain annual and perennial BLW and grasses
Oryzalin	*Oryzalin 4 Pro*	Turf, ornamentals	Selective pre-emergence residual control of annual grasses and some annual BLW
Oxadiazon	*Oxadiazon* (various formulations)	Turf, ornamentals	Selective pre-emergence residual control of annual grasses and some annual BLW
Prodiamine	*Prodiamine 4L, 65 WG*	Turf, ornamentals	Selective pre-emergence control of certain BLW and grasses including crabgrass (*Digitaria* spp.) and *Poa annua*
Rimsulfuron	*Rimsulfuron 25 DF*	Turf, IVM	Post-emergence and soil residual control of certain annual BLW and grasses with pre-emergence control of ryegrass and *Poa annua*
Quinclorac	*Quinclorac 75 DF, 1.5L*	Turf	Selective post-emergence control of annual grasses including crabgrass (*Digitaria* spp.) and certain BLW
Triclopyr	*2-D* (+ clopyralid)	Turf, IVM	Selective control of annual and perennial BLW
Trifluralin	*T/I 2.5G*	Ornamentals	Selective pre-emergence control of annual grasses and BLW
2,4-D dimethylamine	*3-D* (+ mecoprop + dicamba) 2DQ (+ dicamba + quinclorac)	Turf, IVM	Selective control of many annual and perennial BLW

Source: Quali-Pro

Table 3.8. AMVAC's non-crop insecticide portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Acephate	*Orthene*	PCO	Controls cockroaches, ants, crickets, wasps, earwigs and other insects
Bifenthin	*Wisdom* (various formulations)	Turf, ornamentals, landscape	Controls ants, mole crickets and other insect pests
Dichlorvos	*Insect Shield, Nuvan*	Homes, farm storage and other buildings	Vapour action controls ants, cockroaches, bees/wasps, moths, flies and mosquitoes
Naled	*Dibrom*	Public health	Fast knockdown and kill of adult mosquitoes and flies ('restricted use' in US)
Permethrin	*Prelude*	PCO	Termites, wood-infesting beetles, bees, wasps

Source: AMVAC

3.5 Arysta LifeScience

In early 2015, US agrochemical and specialty chemical company, **Platform Specialty Products** (Miami, Florida), completed the acquisition of **Arysta LifeScience** for some $3.5 billion. In 2014, Platform also acquired Belgian agrochemical company Agriphar for some €300 million in October 2014 and Chemtura AgroSolutions for around $1 billion. The three businesses operate under the Arysta name and the global headquarters for the agrochemical business is moving to Cary, North Carolina.

In the non-crop sector, Arysta is particularly focused on **turf in the US** with a small product range (Table 3.9).

In 2014, Arysta granted an exclusive licence to FMC to develop, market and sell the fungicide, *Disarm* (fluoxastrobin), and the herbicide, *Xonerate* (amicarbazone), in the turf and ornamental sector in the US and Canada. Arysta stated that the objective was to concentrate on its growing portfolio of agricultural crop protection products.

Table 3.14. Bayer's non-crop herbicide portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Aminocyclo-pyrachlor	*Method* *Perspective* (+ chlorsulfuron) *Streamline* (+ metsulfuron-methyl) *Viewpoint* (+ imazapyr + metsulfuron-methyl)	IVM	Brush control
Bromacil	*Hyvar* *Krovar* (+ diuron)	IVM	Broad-spectrum control of herbaceous weeds and woody plants, especially perennial grasses
Chlorsulfuron	*Telar*	IVM (range and pasture)	Pre- and post-emergence control of BLW
Dicamba	*Celsius WG* (+ iodosulfuron-methyl-sodium + thiencarbazone-methyl)	Turf, ornamentals	Selective post-emergence control (with good turf safety at high temperatures) of BLW and some grasses.
Diclofop-methyl	*Illoxan*	Golf	Post-emergence control of goosegrass in established bermudagrass turf when applied during the one-leaf to one-tiller growth stages.
Ethofumasate	*Prograss* (EC and SC formulations)	Turf, ornamentals	Post-emergence control of important grasses and some BLW, including residual pre-emergence control of *Poa annua*
Fenoxaprop-p-ethyl	*Acclaim Extra*	Turf, ornamentals	Selective post-emergence control of weed grasses in turf: barnyardgrass, foxtail species, goosegrass, hairy crabgrass, Japanese stiltgrass, Johnsongrass (seedling), large crabgrass, *Panicum* species, sandbur, silver crabgrass, smooth crabgrass, sprangletop
Foramsulfuron	*Revolver* *Derigo* (+ foramsulfuron, + thiencarbazone-methyl)	Turf, ornamentals, IVM	Post-emergence control of bentgrass, centipede grass (suppression), Dallis grass (suppression), goose grass, Kentucky bluegrass, *Poa annua, Poa trivialis*, ryegrass, tall fescue

Table 3.19. Dow's US fungicide portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Mancozeb	*Dithane, Fore Rainshield*	Turf, ornamentals	Broad spectrum, non-systemic, protective control of blights, mildews, scabs, *etc*
Myclobutanil	*Eagle 2EW*	Turf, ornamentals	Broad spectrum, systemic triazole with protective, eradicative and curative action

Source: Dow

Table 3.20. Dow's US insecticide portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Chlorpyrifos	*Dursban*	Turf, ornamentals	Control of insect pests, including ants, borers, cutworms, fall webworms, gypsy moths, leaf feeding beetles and mole crickets
Hexaflumuron	*Recruit, Sentricon*	PCO	Termites
Noviflumuron	*Recruit, Sentricon*	PCO	Termites
Spinosad	*Conserve, Matchpoint*	Turf, ornamentals	Fast action controlling pests such as thrips and leaf miners
Sulfoxaflor (*Isoclast*)	*Transform, Closer, XXpire*	Turf, ornamentals	Control or suppression of aphids, fleahoppers, plant bugs, stink bugs, whiteflies and certain psyllids, scales and thrips
1,3-dicloropropene	*Curfew*	Turf, ornamentals	Liquid soil fumigant for management of nematodes

Source: Dow

3.9 DuPont

The shareholders of **DuPont** and Dow approved the proposed merger between the companies in July 2016 and, subject to regulatory approval, the merger is expected to finalise before the end of 2016. After the merger, DowDuPont will spin off three businesses focused on agriculture, material sciences and specialty products. The spin-offs were expected to be completed within 18-24 months of the merger being finalised.

DuPont has been divesting its interests in non-crop sectors for a number of years:

- American Vanguard (Amvac) acquired DuPont's global business assets for bromacil in mid 2015. The acquisition was made through the company's international subsidiary, Amvac Netherlands. The assets divested include the *Hyvar* (bromacil) and *Krovar* (diuron + bromacil)

Table 3.33. Nufarm's non-crop PGR portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Benzyladenine	*RiteWay* *Fascination* (+ gibberellins)	Ornamentals	Increases lateral or basal branching, promotes flowering and reduces overall plant height Delays leaf yellowing, increases flower size and number, prolongs flowering, plant vigour and growth
Gibberellic acid	*ProGibb T&O*	Turf, ornamentals	Promotes stem elongation and flowering
Prohexadione calcium	*Anuew*	Turf	Reduces mowing frequency and clippings; improves turf quality, density and appearance
Uniconazole	*Sumagic*	Ornamentals	Enhances floral density and foliage colour, improves stress tolerance, increases plant shelf life

Source: Nufarm US

3.16 S C Johnson

S C Johnson is a US-based household products company selling worldwide. Pest control products comprise a major line of world famous brands including *Autan* (personal mosquito and biting insect repellent) and *Raid* (home and garden insecticides). Consumer-friendly features such as pack and container design and use of fragrances are widely used to achieve competitive advantage and brand loyalty. Products are heavily differentiated by use of brand extensions to target specific uses and customer needs.

S C Johnson's brands are shown in Table 3.34.

[1] Often used in mixtures

[2] *Raid* is the brand name for US and other English speaking countries; *Baygon* is used in Europe, Asia, Latin America, Africa

Table 3.34. S C Johnson's pest control portfolio		
Active Ingredient[1]	**Brand[2]**	**Key Targets**
Abamectin	*Raid/Baygon*	Ants
Citronella oil	*Off*	Insect repellent
Cyfluthrin	*Raid/Baygon, Off*	Mosquitos and other flying insects
Cypermethrin	*Raid/Baygon*	Cockroaches Wasps, hornets
d-Allethrin	*Raid/Baygon*	Mosquitos and other flying and crawling insects
d-phenothrin	*Raid/Baygon*	Mosquitos and other flying and crawling insects

Table 3.42. Syngenta's US non-crop PGR portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Paclobutrazol	*Bonzi* *Trimmit 2SC*	Ornamentals Turf	Stem shortening for compact and sturdy plants, deeper green foliage and longer shelf-life Suppresses *Poa annua* and controls growth of hybrid bermudagrass, bentgrass, bluegrass and perennial ryegrass on fairways, tees, and roughs
Trinexapac-ethyl	*Primo MAXX*	Turf	Promotes denser, healthier turf better able to withstand stresses including heat, drought, diseases and traffic. Vertical shoot growth is slowed, while growth of rhizomes, stolons, tillers and roots are stimulated

Source: Syngenta

3.19 Valent

Valent USA Corporation is a wholly owned subsidiary of Sumitomo Chemical Company Ltd, based in California, USA. In 2009, Valent USA Corporation and Valent BioSciences Corporation, formerly a unit of Abbott Laboratories, became aligned under common leadership. In 2014, Valent granted Nufarm marketing and distribution rights to Valent's branded products for the US turf, ornamental and aquatics markets. Sumitomo owns a 23% stake in Nufarm and the companies are collaborating in a number of markets worldwide.

Valent's portfolios of herbicides, fungicides, insecticides and PGRs are presented in Tables 3.43 – 3.46, respectively.

Table 3.43. Valent's non-crop herbicide portfolio			
Active Ingredient	**Products**	**Sectors**	**Key Targets and Features**
Bispyribac-sodium	*Tradewind*	Aquatic	Post-emergence control of surface, submersed and emergent aquatic weeds, *e.g.* hydrilla, with long residual action
	Velocity	Turf	Post-emergence control of *Poa annua* and *Poa trivialis* and certain BLW; also suppresses dollar spot

Syngenta herbicides					
Active ingredient	**Pre-emergence**	**Post-emergence**	**Grasses**	**BLW**	**Residual effect**
Fluazifop-p-butyl					
Glyphosate					
Mesotrione					
Prodiamine					
S-metolachlor					
Simazine					
Trifloxysulfuron					

Other herbicides					
Active ingredient	**Pre-emergence**	**Post-emergence**	**Grasses**	**BLW**	**Residual effect**
2,4-D					
Chlorsulfuron					
Clopyralid					
Isoxaben					
Mecoprop					
Metsulfuron-methyl					
Oxyfluorfen					
Sulfmeturon-methyl					
Triclopyr					

4.5.3 New developments

In 2016, New Zealand's Environmental Protection Authority (EPA) approved the use of Syngenta's mesotrione on turf as *Tenacity*.

Bayer CropScience received approval in California in 2014 for its turf herbicide, *Tribute Total* (thiencarbazone-methyl + foramsulfuron + halosulfuron-methyl). It controls 55 grass and BLW including dallisgrass (*Paspalum dilatatum*), goosegrass (*Galium aparine*) and clumpy ryegrass (*Lolium perenne*).

Thiram					
Triadimenol					Trifloxystrobin
Trifloxystrobin					Iprodione, triadimenol
Triticonazole					Chlorothalonil, pyraclostrobin
Vinclozolin					
Zn/Mn Bisdithiocarbamate					

Source: Pesticide Manual, University of Hertfordshire Pesticide Properties Database, Agrow

5.4.4 Biofungicides

Biofungicides, with their good toxicological and environmental profiles, and 'green image', are becoming more important in non-crop markets. Some examples are presented in Table 5.2.

Table 5.2. Examples of biofungicides sold in non-crop sectors

Species	Product	Sector	Key Targets and Features
Agrobacterium radiobacter strain K1026	*NOGALL* (BASF)	Propagation stock of ornamentals	Crown gall, caused by soil bacterium *Agrobacterium tumefaciens*
Bacillus subtilis	*Subtilex NG* (BASF)	Greenhouse ornamentals	Damping-off and other root diseases caused by soil-borne pathogens, *e.g. Rhizoctonia solani*, *Pythium* spp., *Fusarium* spp., powdery mildew (*Leveillula taurica, Oidiopsis taurica, Sphaerotheeca* spp., *Erysiphe* spp.)
	Rhapsody (Bayer)	Turf, landscape plants, forestry	Anthacnose, bacterial diseases, black spot, botrytis, downy mildew, leaf spots, *Phytophthora* spp., rusts, scabs
Trichoderma fertile	*TrichoPlus*	Flowers	Soil borne root diseases, particularly *Rhizoctonia* spp., *Pythium* spp. and *Sclerotinia* spp.

Source: BASF, Bayer CropScience

5.4.4.1 *New developments*

AgBiome Innovations (Research Triangle Park, North Carolina, USA) expects to obtain US EPA approval and introduce a new biofungicide to the Turf and Ornamentals market in early 2017. The company has an agreement with US specialty agrochemical company **SePRO Corporation** to commercialise the broad-spectrum biofungicide.

Marrone Bio Innovations (MBI - Davis, California) received Canadian approval in mid 2016 for two *Reynoutria sachalinensis* extract-based residential products. *Regalia Liquid Fungicide Ready-to-Spray*

6.4.3 Insecticides for mosquito nets

One particular application method for insecticides is the impregnation of mosquito nets as a means of vector control to combat the spread of malaria (see also Section 8.8). Companies particularly active in this area include BASF, Bayer, Sumitomo and Syngenta (see Chapter 3). The following products are available:

BASF: Interceptor nets are coated with alphacypermethrin

Bayer: LifeNet technology is based on deltamethrin

Sumitomo: Olyset nets are impregnated with permethrin

Syngenta: Nets treated with **IconMaxx (**lamda-cyhalothrin) using a microcapsule formulation and a binding agent will give protection for 20 washes as recommended by WHO

6.4.4 Bioinsecticides, bio and repellents

Bioinsecticides based on micro-organisms, nematodes or semiochemicals (pheromones) are becoming established in non-crop markets, especially where 'green' products attract a premium. Important examples are listed in Table 6.1.

Table 6.1. Bioinsecticides used in non-crop markets

Active ingredient	Brand name and manufacturer	Use
Bacillus firmus (strain I-1582)	*Nortica,* Bayer	Nematodes in turf
Bacillus thuringiensis	Various brands by *e.g*. Bayer, Valent	Fast control of mosquito larvae including *Aedes and Culex* spp. in public health; fungus gnats, tent caterpillar and various bagworms, looper, tobacco budworms and armyworms in ornamentals
Chromobacterium substugae strain PRAA4-1T	*Grandevo PTO*, Marrone Bio Innovations	Control of aphids, whiteflies, thrips and lepidopteran pests in turf and ornamentals
Helicoverpa armigera nucleopolyhedrovirus	*Helicovex*, Andermatt Biocontrol	Control of cotton bollworms (*H. armigera*) and budworms (*H. punctigera*) on a range of crops including ornamentals
Heterorhabditis bacteriophora	*Nemasys G*, BASF *Nemasys H*, BASF	Nematode effective against larval stages of garden chafer grubs; black vine weevil (*Otiorhynchus sulcatus*) of ornamentals
Paecilomyces fumosoroseus strain FE 9901	*NoFly* WP, Novozymes BioAg	Control of whiteflies and thrips on greenhouse ornamentals