Biopesticide
Industry Alliance

Advancing
Knowledge
About
Biopesticides

Biopesticides in a Program with Traditional Chemicals Offer Growers Sustainable Solutions

Contents

Introduction.. 3

Biopesticides Offer Significant Benefits to Growers................................. 3

What is a Biopesticide?.. 4

Biopesticides Can Enhance Crop Quality... 4

Biopesticides are Partners to Traditional Pest Controls................................ 5

Biopesticides Allow Labor and Harvest Flexibility.. 5

Biopesticides are Soft on Beneficial Insects.. 5

Residue Management is Easier with Biopesticides....................................... 6

Environmental Safety with Biopesticides... 6

Types of Biopesticides.. 6

Opportunities and Challenges for Growers... 11

Market and Technology Overview.. 12

Significant Growth Expected in the Global Pesticide Market......................... 12

Biopesticide Regulation and Legislation.. 13

Population Growth, Increasing Environmental Awareness Fuel
Demand for Biopesticides.. 14

New Technologies Create New Markets... 15

Summary and Sources... 16

Introduction

The need to feed an ever-growing global population combined with increasing demand for sustainable agricultural practices has fueled a significant rise in demand for biopesticides. Biopesticides offer unique benefits all along the food value chain, providing additional options for growers, buyers, dealers, consultants and retailers. While biopesticides have been around for more than 50 years, the market has experienced its most significant period of growth — in terms of both sales and user acceptance — over the past five years.

In the early years of biopesticide development, some products promised results but did not deliver. However, the commercially viable biopesticides found success in the market and still more biopesticide technologies have been developed that give growers more targeted and effective pest management options. Regulatory changes, consumer demand for low residues, and the need for even more productive farming practices are inescapable market forces — biopesticides offer solutions in all of these areas. The result is increasing acceptance of biopesticides as an effective partner in crop protection programs.

Biopesticides Offer Significant Benefits to Growers

Managing pests in ways that leave little or no toxic residues, have minimal impact on non-target organisms, and are not prone to pest resistance has always been a challenge in modern agricultural systems. Additionally, enhancing product quality, residue management, labor and harvest flexibility and worker and environmental safety are all challenges growers face. Consumers are becoming more aware of environmental concerns and are asking for chemical-free crops.

Biopesticide products can help growers with all of these issues.

What is a Biopesticide?

As defined by the United States Environmental Protection Agency (EPA), biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria and certain minerals. In commercial terms, biopesticides include microorganisms that control pests (microbial pesticides), naturally-occurring substances that control pests (biochemical pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants). Biopesticides are employed in agricultural use for the purposes of insect control, disease control, weed control, nematode control and plant physiology and productivity.

Plant growth regulators (PGRs), which exhibit no pesticidal activity, are regulated as biopesticides by the EPA. PGRs are compounds that can promote, inhibit or modify the physiology of plants.

Benefits of Biopesticides to Growers Include:

- **resistance management**
- **enhanced crop quality**
- **partner to traditional chemicals**
- **labor and harvest flexibility**
- **maintains beneficial insects**
- **environmental safety/no residue issues**

In addition, biopesticides:

- **provide a strong return on investment**
- **are a sustainable technology**
- **add value at the grower, distributor and retailer levels**

Biopesticides Help with Resistance Management

Insect pests, pathogens and weeds all have the ability to develop resistance quickly. Many pest populations have multi-chemistry detoxification mechanisms that allow them to resist the effects of chemical applications. Constant use of a few traditional pesticides leads to resistance, and eventually the products become less effective. If they are properly used, biopesticides can slow this process down, lengthening the effective field life of all products. Biopesticides typically have different and more complex modes of action than synthetic pesticides and are an important complement to them in an integrated pest management program. As new classes of low-impact, "softer" chemistries continue to be introduced to commercial growers and educators, the challenge of resistance management must be met proactively through thoughtful use of diverse product choices for season-long pest control programs.

Biopesticides Can Enhance Crop Quality

Crop quality is of utmost importance to growers and consumers alike. Plant physiology is highly responsive to the prevailing environmental conditions and plays a critical role in both quantity and quality. Active management of plant physiology plays an important role in crop productivity, and biopesticides, particularly those in the plant growth regulator category (PGRs), are key tools in this regard. Characteristics such as fruit size, taste, texture, shape, color, firmness and shelf life can all be enhanced by careful use of plant growth regulators. In addition, some PGRs can give a boost to plant health by increasing the root mass or enhancing resistance to pests and disease. PGRs have the added benefit of being non-toxic. No harmful residues remain to delay handling or consumption.

Biopesticides are Partners to Traditional Pest Controls

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of cultural, biological and chemical means to control pests, while minimizing economic, public health and environmental risks. Biopesticides are among the most highly effective tools for achieving crop protection in an IPM program; toxicity and impact on the environment are minimal or non-existent. However, real world challenges often dictate that IPM systems use all control methods, including conventional chemistries, to optimize productivity and sustainability. Research, field trials and performance history prove that the most effective IPM programs typically consist of biopesticides used in combination or rotation with traditional chemistries. This optimizes the grower's ability to manage pests, manage resistance and minimize the environmental impact of the pest controls used.

Biopesticides Allow Labor and Harvest Flexibility

Coordinating the harvest with availability of labor is one of the primary challenges of a grower. Unseasonal warmth or cold, excessive rain or an upcoming early frost complicates the issue. Biopesticides are important

tools for an agricultural manager in several ways. Most biopesticides have short restricted entry intervals, allowing workers to safely return to the fields with minimal delay. Many biopesticides have short pre-harvest intervals, which allow more flexibility in harvest and shipping schedules.

Plant growth regulators can help the grower time the ripening of the crop. For example, some PGRs inhibit the formation of ethylene, a natural plant hormone involved in fruit maturation, ripening and abscission. Ethylene inhibitors can help growers with harvest scheduling as well as the maintenance of fruit quality and storage.

Biopesticides are Soft on Beneficial Insects

While many insect species have a negative impact on crop production, beneficial insects actually help. Beneficial insects are often pollinators, or they may be a natural predator to an insect pest. Several species of bees, wasps, beetles and flies fall into this category. One key value of biopesticides is that they usually target specific pests, pathogens or weeds without disrupting the beneficial components of an agro ecosystem. By allowing beneficial organisms to remain unscathed, biopesticides allow the natural enemies of damaging insects to play a complementary role in pest control.

Residue Management is Easier with Biopesticides

Today's "Green Movement" means that consumers are more aware than ever of chemicals used in food production. Many consider produce grown with minimal or no chemical application to be healthier, safer and better for the environment. This is particularly true in the export market.

Listening to the demands of their customers, several large European multinational grocery stores and food processing companies are already requiring significantly lower pesticide residues than the current government-mandated Maximum Residue Levels. The governments of Denmark, Sweden and The Netherlands have required a 50% reduction in on-farm chemical pesticide use.[8] In 2009, the European Union voted to phase out more than 200 chemical pesticides.[8] Retail chains such as Tesco and Wal-Mart are increasingly demanding chemical-free produce.[11] Since most biopesticides are exempt from residue limits, their use, particularly late in the growing cycle, helps growers to meet these lower residue requirements while still protecting their crops. Adding biopesticides to the rotation with traditional chemical controls means cumulative residue levels are reduced without sacrificing food safety or quality.

Environmental Safety with Biopesticides

Increasingly, environmental stewardship and Best Management Practices are at the forefront of commercial farming operations. Indeed, the art of being a top grower depends upon maximizing return on investment while at the same time being a responsible steward of the land — land that future generations will depend upon for their livelihood. Biopesticides help on both fronts by managing pests without creating negative impacts on the environment. They have little or no toxicity to birds, bees, fish and other wildlife, break down quickly in the environment and may serve to reduce conventional pesticide applications through their use in integrated pest management and resistance management programs.

Types of Biopesticides

Biopesticide products fall into two major categories: microbial and biochemical. Within each of these, there are various types of products, each with its own mode of action.

Microbial ~ in this category, the active ingredient is a microorganism that either occurs naturally or is genetically engineered. The pesticidal action may be from the organism itself or from a substance it produces. The following microorganisms are used in microbial biopesticides:

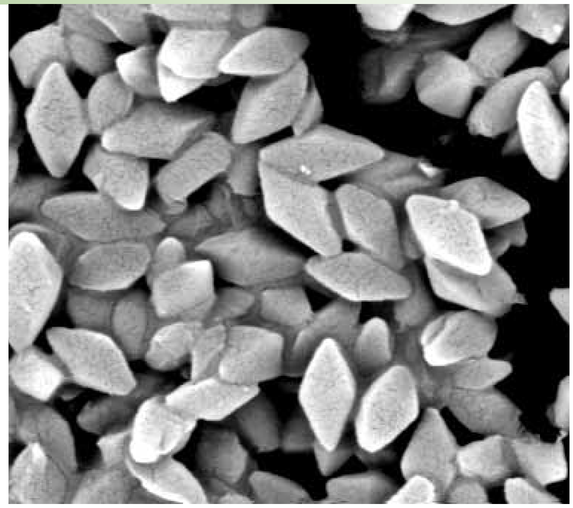
Bacteria~ Biopesticides based on bacteria have been used to control plant diseases, nematodes, insects and weeds. They control pests in a number of ways: by producing toxins outcompeting the damaging pathogen, producing anti-fungal compounds and by promoting root and top growth. *Bacillus thuringiensis* (Bt), which targets larvae and *Pseudomonas syringae*, which controls bacterial spot are examples of microbials.

Fungi ~ Fungal biopesticides are relatively new. They may be used to target nematodes, mites, insects, weeds or other fungi. Like bacteria, they may act by out-competing the targeted pathogen or producing toxins. They may also attack and parasitize plant pathogens or insects. *Trichoderma harzianum* is a fungi that is also a fungicide, targeting *Pythium, Rhizoctonia* and *Fusarium*.

Nematodes~ Nematodes are colorless roundworms. Many are parasitic to plants and cause serious damage to crops. However, some are actually beneficial, attacking insect pests. The two main nematodes used for biopesticidal purposes are *Steinernema* spp. and *Heterorhabditis* spp.[12]

Protozoa~ Protozoa are single-celled organisms that live in both water and soil. While most protozoa feed on bacteria and decaying organic matter, many species are insect parasites. In particular, one species of protozoa, *Nosema locustae*, is used to control grasshopper, locust and crickets on rangeland.

Viruses~ Microbial biopesticides known as baculoviruses are a family of naturally-occurring viruses known to infect only insects and some related arthropods. Most are so host-specific that they infect only one or a few species of Lepidoptera larvae, which makes them ideal for management of crop pests with minimal harm to beneficials. The granulosis virus of *Cydia pomonella*, the codling moth, and the nuclear polyhedrosis virus of *Heliothis/ Helicoverpa* spp., the corn earworm, are two examples.



Bacillus thuringiensis

Yeast ~ Some yeast species that naturally occur in plants have been developed into products that help to control postharvest decay and/or stimulate the plant's immune system. For example, *Candida olephila* Strain O, first isolated from Golden Delicious apples, has been developed into an effective biopesticide for the control of post-harvest fruit rots.

Biochemicals ~ Biochemical pesticides are naturally occurring or synthetically derived compounds that are structurally similar (and functionally identical) to their natural counterparts. Unlike conventional chemicals, which usually directly attack and kill the pest, biochemical biopesticides are characterized by a non-toxic mode of action that may affect the growth and development of a pest, its ability to reproduce, or pest ecology. Biochemicals might also be used to effect the growth and development of treated plants and their fruit, including during the postharvest period. Biochemicals fall into the categories below:

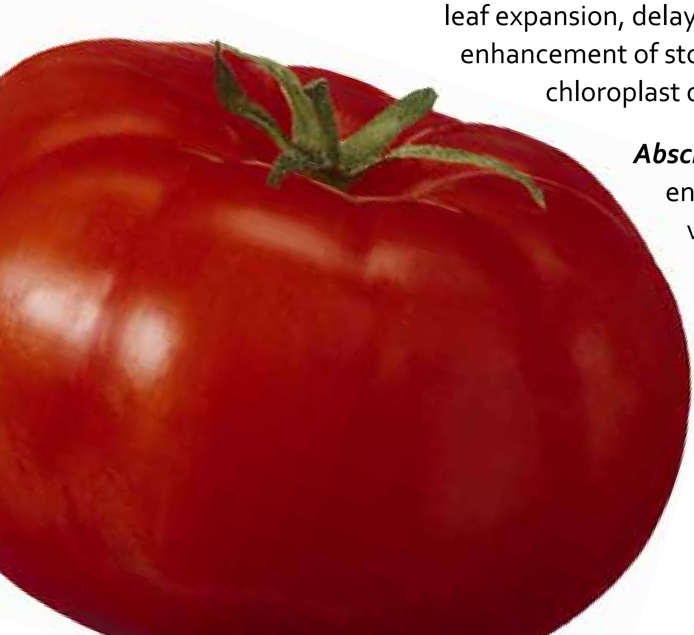
Plant Growth Regulators ~ Plant growth regulators (PGRs) are compounds that effect major physiologic functions of plants, such as growth rate, seed germination, bolting, fruit set and ripening, branching and many others. They may be naturally-occurring or synthetically manufactured to mimic the function of the natural substance. Many are plant hormones, but there are also other compounds that have an impact on plant growth, including a variety of secondary metabolites produced by plants and some plant-associated microbes. As the benefits of PGRs have become better understood by growers, their use has increased. They provide value through their ability to maximize productivity and quality, improve consistency in production and to overcome genetic and abiotic limitations to plant productivity.

There are five major classes of natural plant hormones. Under each class there are a number of PGR products that play specific roles in optimizing crop yield and quality.

Gibberellins ~ Gibberellins are an important factor in cell elongation, stem growth, bolting in long-day plants, induction of seed germination, enzyme production during germination, fruit setting and growth and induction of maleness in dioecious flowers.

Cytokinins ~ Cytokinins are involved in growth promotion through cell division, fruit abscission, growth of lateral buds, leaf expansion, delay of leaf senescence, enhancement of stomatal opening and chloroplast development.

Abscisic acid ~ can influence water relations via stomatal closure, inhibit shoot growth, affect seed dormancy, increase fruit coloring and promote leaf and fruit abscission.



Ethylene ~ can stimulate lateral branching, stimulate defense responses to injury, break dormancy, abscise leaves, flowers and fruit, induce flowering and stimulate fruit ripening.

Auxins ~ can promote growth through cell enlargement, release apical dominance, and influence rooting, leaf senescence, flowering, fruit set and growth, fruit ripening and leaf and fruit abscission.

There are a variety of concrete examples of how PGR's meet the needs of growers in the fresh produce market. These include:

- ***Improved fruit quality:*** Gibberellins reduce russet on apples, improve firmness in cherries and rind quality in citrus. Abscisic acid enhances the red color on red grapes and ethylene aids in ripening of fruit crops.
- ***Improved yield:*** Gibberellins increase the fruit size of cherries, table grapes, pineapple and bananas. Gibberellins also improve fruit set on citrus and many other crops and the leaf size and yield are increased on spinach and other leafy vegetables. Cytokinins also increase the berry size of table grapes and ethylene modulation increases fruit set on walnuts.
- ***Overcoming genetic limitations:*** Gibberellic acid improves seed germination of dwarf rice varieties and increases berry size on seedless table grapes. Both gibberellins and cytokinins can also increase fruit size in small apple varieties.
- ***Reduce labor costs:*** Cytokinins and auxins induce thinning of flowers and

fruits. Ethylene modulation allows growers to manage the timing of fruit maturity, and therefore, the harvest. Gibberellins also allow growers to delay the harvest on citrus and cherries.

- ***Extend post-harvest life:*** Ethylene management and ethylene receptor blockage can enhance the shelf life of fruit. Gibberellins extend the green life of bananas and lemons during shipping and storage.

Insect Growth Regulators ~ Most chemical insecticides work by killing insects outright, often targeting the nervous system. Often, beneficial insects are killed as well. Insect growth regulators (IGRs) use a different and more selective mode of action; they disrupt the growth process of insects, preventing them from the reaching reproductive stage. The direct impact of IGRs on target pests combined with the preservation of beneficial insects and pollinators aids growers in maximizing yield and product quality.

IGRs can be divided into two broad categories: those that disrupt the hormonal regulation of insect metamorphosis and those that disrupt the synthesis of chitin, a principle component of insect exoskeletons. Agricultural applications currently focus on the first category of compounds, also known as "hormone mimics."

The most widely used IGR is azadirachtin, which structurally mimics the natural insect molting hormone ecdysone. Immature insects exposed to azadirachtin may molt prematurely or die before they complete a properly timed molt. Insects that survive exposure are likely to develop into a deformed adult incapable of feeding or reproducing.

Since beneficial insects do not feed on the treated foliage, biopesticide insect growth regulators are considered "soft" on beneficial insects such as honeybees, ladybugs, green lacewings and parasitic wasps.

Organic Acids ~ Peracids are highly effective sanitizing agents used for controlling algae and pathogens. Peracids can be used for sanitation of greenhouse surfaces, shock applications for tanks and piping, continuous application at a low concentration and as a bacterial or fungicidal application to plant foliage or roots. A further advantage is that when peracids degrade, the byproduct is oxygen, which is safe and beneficial.

Plant Extracts ~ In order to protect themselves from insect, animal and fungal predators, plants have devised numerous biochemical defenses. Some discourage feeding by insects and herbivores, some have anti-bacterial or anti-fungal activity that provides protection or even immunity from some pathogens, and others have a detrimental effect on nearby plants in order to reduce competition for resources. By studying the diverse chemistries of many different plant species, scientists have discovered many useful compounds that can be used as biopesticides.

These are called plant extracts and provide pest control in a variety of ways:

Insect growth regulators ~ prevent insects from reaching the reproductive stage.

Feeding deterrents ~ are compounds that, once ingested by the insect pest, cause it to stop feeding. Crop damage is inhibited and the insect eventually starves to death.

Repellents ~ are typically compounds that release odors that are unappealing to insects. Examples include garlic or pepper-based insecticides.

Confusants ~ imitate food sources and are used as traps or decoys to lure insects away from crops. They can also be formulated as concentrated sprays designed to overwhelm insects with so many sources of stimuli that they cannot locate the crop.

Allelopathy ~ Some plants naturally produce biochemicals to prevent competition from neighboring plants. Juglone, the allelochemical produced by black walnut trees (Juglans nigra), is toxic to many other plants. Many recently discovered allelochemicals have potential for development as natural product herbicides.

Plant Growth Regulation ~ Some plant extracts can act as effective contact herbicides through a variety of mechanisms such as disrupting cell membranes in plant tissue, inhibiting amino acid synthesis or enzyme production.

Mechanical Control ~ Some plant extracts are powerful natural agents that act directly on weeds. D-limonene, for example, is a degreasing agent that strips the waxy cuticle from weed leaves, causing necrosis, dehydration and weed death.

Fungicidal Control ~ By disrupting cell membrane integrity, deactivating key enzymes and interfering with metabolic processes, plant extracts can act as contact fungicides.

Induced Resistance ~ Crops treated with some plant extracts produce and accumulate elevated levels of specialized proteins and other compounds that inhibit the development of fungal and bacterial diseases. In effect, the crop's immune system is triggered to defend against destructive diseases.

Pheromones ~ Insects release chemical signals, called pheromones, to communicate with others in their species for a variety of reasons. These might include finding a mate, warning others of potential danger or indicating the location of a food source. By using synthetic pheromones that mimic the action of the pests' natural chemical, growers

can disrupt mating cycles or lure pests away from crops. Each year, more than one million acres worldwide are treated with pheromones to control insect damage through mating disruption. Pheromones are also used in traps, allowing growers to predict insect populations and time application of controls.

Minerals ~ Minerals play a key role in a wide range of biopesticide applications that can be divided into three categories:

Barriers ~ act to keep pests away from plant tissues and/or impact pathogen water supply. An example is kaolin clay, which acts as a repellent that coats the plant surface, making it unsuitable for insect feeding or egg laying.

Smothering and/or abrasion ~ one example is diatomaceous earth, which contains fossilized microscopic plants, giving the compound a sharp surface that cuts through insects' exoskeletons, a process that leads to desiccation of the insect. Mineral oils are often used to smother insects in the nesting or crawler phases.

Carrier for other biopesticides ~ minerals are also used as inert carriers for companion biopesticides. In these applications, minerals are included in formulations to deliver or enhance pest control agents, but the mineral itself is considered inert. Talc, kaolin, montmorillonite and attapulgite are just a few.

Plant-Incorporated Protectants ~ Plant-incorporated-protectants, also known as genetically modified crops, are pesticidal substances that plants produce from genetic material that has been added to the plant, such as corn and cotton.

Opportunities and Challenges for Growers

Biopesticide products offer several valuable opportunities for growers, including:

- Biopesticides fit with integrated pest management systems and contribute to environmentally responsible production systems.
- Biopesticides help growers manage maximum residue levels (MRL's), creating more opportunities to export to markets where MRLs have been reduced significantly.
- Growers may strengthen relationships with produce buyers as they improve the timing of harvest and shipping due to biopesticides.
- Biopesticides allow organic growers to control pests while maintaining their certified status.

Biopesticide products offer several challenges for growers, including:

- Frequent monitoring of crops is necessary for proper timing of biopesticide applications.
- The need to work closely with a consultant familiar with biopesticides.
- Traditional programs use chemicals that kill many pests at once. Biopesticides are often targeted for a specific pest, meaning other applications may be necessary to kill pests not controlled by the biopesticide.

Market and Technology Overview

Significant Growth Expected in the Global Pesticide Market

While estimates on the size of the biopesticide market can vary widely, some market studies indicate that during the past five years, the global biopesticide market has grown by nearly 10% per year, from more than $670 million in 2005 to $1 billion in 2010.[7] (For the purposes of this document, plant-incorporated protectants, or PIPs, are treated as a separate class of biopesticides.) Given the increasing consumer demand for chemical-free crops and the increasing number of registered biopesticide products, industry models indicate that the annual biopesticide market could exceed $2.5 billion by 2015.[6]

"Since the early 2000s, in markets where biopesticides are sold, growth rates for biopesticides are generally higher than for traditional chemicals, sometimes by a factor of two."

This recent growth has occurred despite a stagnating overall market for pesticides. Since the early 2000s, in markets where biopesticides are sold, growth rates for biopesticides are generally higher than for traditional chemicals, sometimes by a factor of two.[4] Industry models indicate that sales of traditional chemical pesticides will either increase at a negligible rate along with inflation and commodity prices — or decline slightly — through 2015.
Presently, biopesticides represent 2-6% of the approximately $40 billion global pesticide market. That share is expected to increase significantly through 2015 and beyond.

In terms of geography, North America and Western Europe are the leading consumers of biopesticides worldwide, having purchased approximately $600 million of biopesticide products in 2008.[1] According to market reports, that figure could exceed $1 billion by 2015.[1] Asia-Pacific represents another fast-growing biopesticide market, with sales in that region projected to top $350 million by 2012.[6]

In terms of crops, an estimated 55% of all current biopesticide sales are for use on orchard crops. Overall, biopesticides are most

widely used on specialty crops, although these technologies are being used to an increasing extent on corn, soybeans, forage crops, and applications in the areas of public health and forestry.

Biopesticide Regulation and Legislation

In the United States, biopesticides are regulated by the same laws and regulations as traditional chemical pesticides. All biopesticide product registrants must submit data to the Biopesticides and Pollution Prevention Division (BPPD) of the Office of Pesticide Programs (OPP) regarding the composition, toxicity, degradation, and other characteristics of the product.[14] This information is reviewed to ensure that a product will not adversely affect human health or the environment.

The EPA regulates three major classes of biopesticides: biochemical pesticides, microbial pesticides, and plant-incorporated protectants.

Given that biopesticides tend to pose fewer risks than chemical pesticides, the EPA generally requires less data to register a biopesticide than to register a chemical pesticide. As a result, new biopesticides are often registered in less than a year, compared with an average of more than three years for chemical pesticides.

Although the registration process for biopesticides may be less costly than for chemical pesticides, field testing of biopesticides on high-value specialty crops can be disproportionately expensive for small biopesticide manufacturers who may realize only a modest return on investment for a product with limited usage. The United States Department of Agriculture's (USDA) Interregional Research Project Number 4 (IR-4) was established to assist these minor acreage, specialty crop producers in obtaining EPA tolerances and new registered uses for biopesticide products.

In the European Union (EU), recent legislation has synchronized with political will to both reduce traditional chemical usage in agriculture and increase the use of biopesticides.[5]

"Overall, the number of conventional pesticides approved for agricultural use in the EU has been reduced from an all-time high of about 1,000 to a current list of 300."

The Sustainable Use Directive, signed in 2009, calls for EU governments to introduce national action plans by 2012 for the significant reduction of chemical usage in agriculture.

France, Denmark, and Sweden already have aggressively reduced overall agricultural chemical use by more than 30%. Through its Ecophyto 2018 plan, which includes a robust grower-education component, France intends to reduce its agricultural chemical usage by 50% by 2018 without affecting yield or revenues.[13] Overall, the number of conventional pesticides approved for agricultural use in the EU has been reduced from an all-time high of about 1,000 to a current list of 300.[10]

As of 2008, the EU had 77 active substances registered as biopesticides, compared with 279 registered in the United States. Biopesticides are regulated in the EU in the same manner as chemical pesticides. The Organisation for Economic Co-operation and Development (OECD), a 34-country group headquartered in Paris, France, assists EU governments in quickly and thoroughly assessing biopesticide risks to humans and the environment.

Population Growth, Increasing Environmental Awareness Fuel Demand for Biopesticides

Several key factors have spurred the significant recent increase in demand for biopesticide products.

From a macro perspective, the agriculture industry is undergoing rapid change. As world population continues to increase — from 6 billion in 2000 to 6.8 billion in 2010 to a projected 9 billion by 2050 [10] — and nutritional habits change, more food must be produced. Some estimate that current food production levels must be doubled by 2050 to satisfy demand.[3] At the same time, arable land, water, and other natural resources are limited. Therefore, the agriculture industry must be more productive than ever before, while decreasing its negative environmental impact. Biopesticide products meet the demands of sustainability.

From the perspective of the general public — the end-consumer of food products — chemical pesticides have been associated, fairly or unfairly, with the potential for pollution and health hazards. This perception is strongest in areas where urban and suburban housing abuts agricultural land. Many consider produce grown with less chemical inputs as healthier, safer, and friendlier for the environment. Although a significant number of these end-consumers may not be intimately familiar with biopesticides, they do perceive biopesticides to be a generally agreeable alternative to chemicals in a sustainable, integrated approach to agriculture.

The European model relies on engagement from the entire food production chain to spur new product acceptance.[5] Under that system, all sectors, including produce buyers, retailers, and food processors, support a

product to drive it forward. Currently, in Europe, all sectors perceive positive benefits from biopesticides, and those perceptions — along with legislative mandates for 2012 — are contributing to rapid acceptance and use of biopesticide products by growers.

In the United States, demand is being driven, in part, through the financial influence of large retailers such as Wal-Mart and McDonald's Corporation, who, in response to shareholder demand, are authorizing their growers to reduce use of chemical pesticides and to increase use of alternative crop protection such as biopesticides.

New Technologies Create New Markets

One of the most important factors in the recent growth of the biopesticide market is the innovation in biopesticide technology itself. During the decades of the 1990s and 2000s, significant progress was made in microbial and biochemical research.[7] Manufacturers made advances in the mass production of biopesticides, increased the storage and shelf life of their products, and improved application methods. These successes caused an overall increase in investment in biopesticide research and development.

"Manufacturers made advances in the mass production of biopesticides, increased the storage and shelf life of their products, and improved application methods."

Once solely the domain of smaller manufacturing companies, the biopesticide market is now an investment area for leading agrochemical companies. Given the increasing demand for biopesticides, these companies are including biopesticides in their portfolios either by acquiring products from or forming licensing agreements with smaller companies or by investing in their own new research and development.

In the EU, the systematic review of chemical pesticides that thinned the approved products list from about 1,000 to 300, effectively instigated research into alternative products with new modes of action. The potential for further new product discoveries will have a significant impact on the industry going forward. To date, only a small percentage of species have been considered for biopesticide usage. Many potential biopesticides remain undiscovered.

Summary and Sources

Biopesticides are an integral part of an IPM program. Growers can still protect their crops while reaping benefits such as labor and harvest flexibility and low impact on beneficials. The additional benefits of helping growers manage resistance and residue levels, as well as options for increasing crop yield with plant growth regulators make biopesticides a valuable component of a crop protection program.

For More Information

Visit the Biopesticide Industry Alliance at http://www.biopesticideindustryalliance.org/

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