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Biopesticide
Industry Alliance

Advancing
Knowledge
About
Biopesticides

Biopesticides Provide More Options Plus Customer Satisfaction for Produce Buyers and Retailers

Contents

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 Produce Buyers and Retailers

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.[13] Plant growth regulators (PGRs), which exhibit no pesticidal activity but instead can promote, inhibit or modify the physiology of plants, are also regulated by the EPA as biopesticides. In commercial terms, biopesticides include microorganisms that control pests (microbial pesticides), naturally occurring substances that control pests (biochemical pesticides), pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) and biochemical plant growth regulators. Biopesticides are employed in agricultural use for the purposes of insect control, disease control, weed control, nematode control, and plant physiology and productivity.

Biopesticides Make Residue Management Easier

Food safety is a primary concern for end-consumers. European and North American consumers have been particularly active on this issue. Therefore, food safety is a vital issue for both produce buyers and retailers. Consumers are increasingly aware of chemical use in food production and the potential for chemical residue on food and are interested in supporting chemical-free production alternatives. Biopesticides represent a viable residue management product and are exempt, in the United States, from residue limits on fresh and processed foods because they leave little to no residue on food. Biopesticides may also be used to manage residue levels for exported produce.

Benefits of Biopesticides to Buyers and Retailers Include:

- **Residue Management**
- **Environmental Safety**
- **Enhanced Crop Quality**
- **Increased Value and Yield**
- **Access to Organic Market**
- **Labor and Harvest Flexibility**

Environmental Safety with Biopesticides

End-consumers' concern for the environment is one of the leading drivers of biopesticide usage. As produce buyers and retailers engage their customers, marketing these environmentally responsible production practices is important.

Non-toxic to non-target organisms, including beneficial insects and wildlife, many biopesticides also are biodegradable. They decompose quickly and do not negatively impact surface water and groundwater. Biopesticides typically are effective in small quantities, which eliminates pollution concerns sometimes associated with traditional chemicals. In addition, biopesticides are manufactured from naturally-occurring raw materials in an environmentally responsible and sustainable manner.

Biopesticides Can Enhance Crop Quality

Biopesticides can markedly improve crop quality by preventing pest damage and promoting physiological benefits in plants, including increased fruit size and enhanced color. Crop quality is vitally important to produce buyers and retailers who tie their reputation to the quality of their produce.

Biopesticides Add Value and Yield

In protecting produce from pests, biopesticides may promote greater crop yield. Increased yield generally results in more favorable prices for produce buyers, who are responsible for finding and negotiating produce prices with their suppliers. Retailers may then pass prevailing market prices to the end-consumer.

Access to Organic Market

Boosted by public perception, organic products continue to be a rapidly growing segment of the world food market. With sales estimated at $52 billion in 2008, organic foods account for only about 1–2% of total food sales worldwide, but are increasing at a rate of approximately 20% per year.[1] This growth corresponds with the growth of the biopesticides market as biopesticides fit into organic systems.

While only about 5% of all current biopesticide use is for organic applications,[5] that percentage is increasing. Many biopesticides are registered for and are effective in certified organic production systems. Certified organic produce is grown according to strict uniform standards that are verified by independent state or private organizations.

Biopesticides Allow Labor and Harvest Flexibility

End-consumers demand freshness in produce. Produce buyers and retailers deliver this freshness by quickly transporting produce from field to store. Biopesticides allow growers to better manage the harvesting and processing schedule by controlling the growth rate of produce. Plant growth regulators (PGRs), for example, may be used to optimize harvest times. PGRs that inhibit the biosynthesis of ethylene in plants can slow down fruit maturation, ripening, and abscission.

Types of Biopesticides

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

Microbial Biopesticides

Microbial pesticides are products derived from various microorganisms (e.g., bacterium, fungus, virus or protozoan) that are used as an active ingredient to control pests. Microbial products may consist of the organisms themselves and/or the metabolites they produce. The microorganism may occur naturally, be dead or alive, or be genetically engineered. Microbial biopesticides are generally divided into six subcategories:

Bacteria ~ Many spore forming and non-spore forming bacteria are known to be effective against a wide spectrum of insects and diseases. More than 90 species of naturally occurring, insect-specific bacteria have been isolated from insects, plants, and the soil. To date, *Bacillus thuringiensis*, or Bt, is the species that has been most successfully developed as a microbial insecticide.

Viruses ~ Baculoviruses are a family of naturally-occurring viruses known to infect only insects and some related arthropods. Most are so specific in their action that they infect and kill only one or a few species of Lepidoptera larvae.

Fungi ~ With complex lifecycles, some fungi are parasitic to various eukaryotes, including plants and insects. Fungi require specific environmental conditions to proliferate and their means of affecting the target pest are diverse.

Protozoa ~ Protozoa are single-celled eukaryotic organisms that exist in both water and soil. While most protozoa feed on bacteria and decaying organic matter, a wide range of protozoan species are insect parasites.

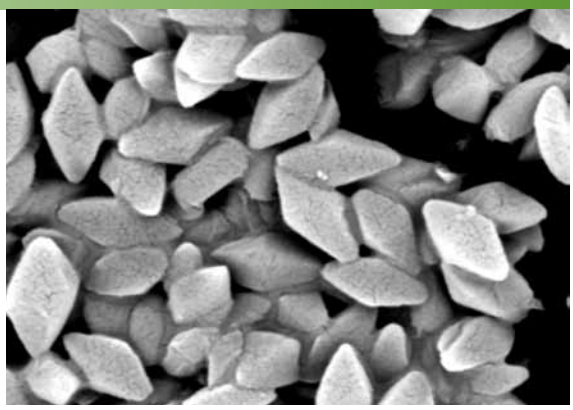
Yeast ~ A variety of non-pathogenic, naturally occurring yeasts have been investigated for their usefulness in controlling plant diseases.

Nematodes ~ Nematodes act as insecticides by invading insect larvae through bodily openings and releasing toxic bacteria that kills the host.

Biochemical Biopesticides

Biochemical biopesticides are naturally occurring compounds or synthetically derived compounds that are structurally similar (and functionally identical) to their naturally occurring counterparts. In general, 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. They also may have an impact on the growth and development of treated plants including their post-harvest physiology. Biochemical biopesticides are generally divided into six subcategories:

Plant Growth Regulators (PGRs) ~ Including both natural and manufactured versions of natural substances that affect major physiological functions of plants, PGRs can promote, inhibit, or modify the



Bacillus thuringiensis

physiological traits of a range of fruit, vegetable, ornamental and agronomic crops. PGRs are used to maximize productivity and quality, improve consistency in production, and overcome genetic and abiotic limitations to plant productivity. There are five major classes of these natural plant hormones: gibberellins, cytokinins, abscisic acid, ethylene, and auxins.

Insect Growth Regulators (IGRs) ~With a unique mode of action, these products prevent insects from reaching a reproductive stage, thereby reducing the expansion of pest populations. 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.

Organic Acids ~ Acids such as peracids are effective sanitizing agents used for control of pathogens and algae. Peracid products can be used for sanitation of greenhouse surfaces, shock applications for tanks and piping, continuous application at a low concentration, and also as a bactericidal or fungicidal application to plant foliage or roots.

Plant Extracts ~ Many plants have developed natural, biochemical mechanisms to defend themselves from weed, insect and fungal attacks. These products act as insect growth regulators, feeding deterrents, repellents, and confusants.

Pheromones ~ Chemical signals that trigger a natural response in another member of the same species, pheromones are used to disrupt pest ecology and reduce crop damage. Synthetic female pheromonea are used as lures to attract males into traps and are also used for mating disruption.

Minerals ~ Minerals play a key role in a wide range of biopesticide applications that can be divided into three categories: those that create barriers that keep pests from plant tissues and/or impact pathogen water supply; those that deliver physical impacts such as smothering or abrasion; and those that act as an inert carrier for companion biopesticides.

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.

Challenges and Opportunities for Produce Buyers

Biopesticide products present several significant opportunities for produce buyers, including:

- Produce buyers may expand their organic product base as the use of biopesticides in crop production facilitates the continuing increase in organic production.
- Produce buyers may market the environmental benefits of its products to its customers. Biopesticides fit with integrated pest management programs and contribute to environmentally responsible production systems.
- Produce buyers may strengthen relationships with growers and customers as they improve the timing of harvest and shipping due to biopesticides.

However, there are several significant barriers for produce buyers, including:

- Grower adoption of biopesticide products has been rapid, but those using biopesticides remain in a minority. Produce buyers have little influence over the adoption of specific crop protection products by growers.
- Given that biopesticide use is still in its formative stages, there remains a general lack of education and knowledge about these products by produce buyers.

Challenges and Opportunities for Retailers

Biopesticide products present several significant opportunities for retailers including:

- Retailers can meet growing consumer demand for safe, environmentally responsible food products by selling produce grown with the use of biopesticide products. The market for such products is immature and retailers may still establish market leadership in this area.
- Retailers may expand their organic offerings to meet end-consumer demand by selling products grown with the use of biopesticide products.
- In response to end-consumer demand, large global retailers may use their

financial influence to dictate grower use of biopesticide products. Wal-Mart, for instance, is joining with industry associations to promote biopesticide technology to growers in Europe and the United States.

Biopesticide products present several significant challenges for retailers, including:

- Although large retailers have the ability to influence product use to growers, adoption of biopesticide technology is still in its early stages.
- Given that biopesticide use is still in its formative stages, there remains a general lack of knowledge about these products by both retailers and end-consumers.
- While retailers may effectively market "food safety" and "environmental responsibility" to end-consumers, marketing the use of biopesticides is less effective.

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.[8] (For the purposes of this paper, 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. [7]

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. [5] 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.[3] According to market reports, that figure could exceed $1 billion by 2015.[3] Asia-Pacific represents another fast-growing biopesticide market, with sales in that region projected to top $350 million by 2012.[7]

In terms of crops, an estimated 55% of all current biopesticide sales are for use on orchard crops.[3] 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.[13] This information is reviewed to ensure that a product will not adversely affect human health or the environment.

"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."

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.[1]

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.[6] 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 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.[11] 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.[11]

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 the perspective of the general public — the end-user of food products — chemical pesticides have been associated, fairly or unfairly, with the potential for pollution and health hazards."

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[11] — and nutritional habits change, more food must be produced. Some estimate that current food production levels must be doubled by 2050 to satisfy demand.[4] 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.[6] 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.[8] 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.

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.[11] Many potential biopesticides remain undiscovered.

Summary and Sources

Consumers' increasing concern about pesticide residues on food makes the use of biopesticides an important consideration for produce buyers and retailers. Significant lowering of MRLs by regulators in many countries is a trend that is expected to continue. Biopesticides are a key tool to manage these issues all along the food value chain, along with their sustainability, crop quality and harvest flexibility benefits.

For More Information

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

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