EC3019

Introduction to Biological Products for Crop Production and Protection

Tony O. Adesemoye, Extension Plant Pathologist, West Central Research and Extension Center

The Need for Biological Products

The rapid development of agriculture in the last six decades relied mainly on improved crop varieties, modern irrigation methods, and new chemicals, including pesticides and fertilizers. These technologies continue to be very relevant and beneficial to agricultural productivity. In recent years, however, there have been many reasons for the need to improve the strategies of using these technologies as well as to search for new tools. Improvements in the use of biological methods and development of new biological products fit well into the needed improved strategies or new paradigm.

Four examples of why improved strategies and new tools are essential:

- Development of pest resistance to many pesticide modes of action.
- Limited supply and development of new synthetic chemical modes of action.
- Increased grower interest in using alternative products.
- The need for more food to feed the ever-increasing world population.

The same reasons may be attributed to the recent massive investments in the development of new biological products in the agriculture industry. This publication provides information about product terminologies, benefits from using biological products, and how to use the products effectively.

Biological Product Categories and Terminologies

What is a "biological" and how is it different from "biorational" technology? These terms often overlap and have many synonyms. Some biologicals are also soil enhancers or growth enhancers. Some of the products are regulated by the U.S Environmental Protection Agency (EPA) while some are not.

The multitude of other terms used in the market is also confusing to many growers. An explanation of some of them follows.

Biorational Products

Biorationals are non-synthetic input materials in agriculture that are derived from natural sources such as microorganisms, biochemicals, minerals, organic materials, and plant extracts.

Biorationals are nontoxic to people, have minimal or no environmental side effects, and are usually specific to the target. Biorational is a broad term that has two components:

- **Biological products.** Examples of such products are Regalia® by Marrone Bio and Ethos® XB by FMC Corp.
- **Natural, non-biological but environmentally non-toxic products** (activators, adjuvants, elicitors, organic materials, soil enhancers, growth enhancers, and plant growth regulators, e.g., gibberellic acid). Examples of such products are Ryzup® plant growth regulator by Valent Biosciences and Natria® Neem Oil by Bayer Advanced LLC.

Biological Products

Biologicals are products that contain beneficial, naturally occurring microorganisms or microbial derivatives as active ingredients.

A product must have an organism or microbial derivative in it to be described as a biological. Two major types of

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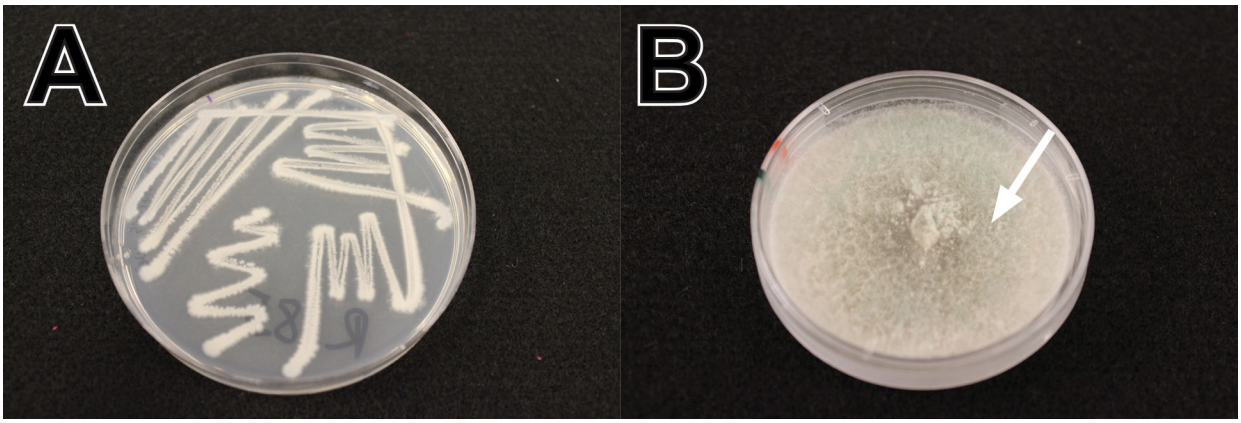

Figure 1. *Bacillus* sp., a beneficial bacterium, (A) and *Trichoderma* sp., a beneficial fungus, (B) growing on culture media.

biologicals described in this publication are biostimulants and biopesticides.

Biostimulants (or enhancers) are substances that enhance plant growth, health, and productivity or provide other direct or indirect benefits to a plant's development. Biostimulant products have been listed to include adjuvants, amino acids, biofertilizers, chitin/chitosan, biochemical materials, fulvic acid, microbial inoculants, and plant growth regulators. Biostimulants that are not from microbial sources are considered to be biorationals.

It is important to know that some biostimulants and growth enhancer products are not required to be registered and may not be regulated by the EPA if they are only for growth promotion without any claim for pest control. Detailed information on the mode of action or efficacy may not be available for nonregulated products.

Biopesticides are protectors, products that protect against or are used to directly control fungal and bacterial pathogens, insect pests, or weeds. These may be termed biofungicides or biobactericides, bioinsecticides, or bioherbicides. Biopesticides are generally subject to EPA registration and regulations. Biological products are typically available as a plant enhancer or a biopesticide. Products that provide both plant biostimulation and bioprotection simultaneously are less common.

Beneficial Microorganisms as Active Ingredients in Biological Products

Beneficial microorganisms are organisms whose relationships with plants are mutually beneficial. These organisms are naturally present in the plant environment or natural habitat. Predominantly fungi or bacteria (*Figure 1*), they may be free-living in the soil or in symbiotic associations with plants. Beneficial microorganisms obtain nutrients from the plant root exudates. In return, the microorganisms benefit plants by protecting them against pathogens and pests. They help to increase plant root growth and improve soil structure. They also enhance nutrient availability, nutrient uptake, and use efficiency.

Additionally, they help plants to alleviate abiotic stress conditions such as limited soil moisture and high salt. It is easier for crops to take advantage of these benefits when a good population of beneficial microorganisms is present in the roots. This is why beneficial microbes or microbial derivatives are useful as active ingredients in biological products.

Examples of microorganisms in many biological products include:

- **Bacteria**: the most common are *Bradyrhizobium*, *Rhizobium*, *Streptomyces*, and a bacteria group called plant growth promoting rhizobacteria (PGPR) such as *Bacillus*, *Pseudomonas*, and *Burkholderia*.
- **Fungi**: the most common fungi are *Trichoderma* and mycorrhizae, especially *Glomus*.

Specific Benefits of Biological Products

Biological products might work in a number of ways within the complex soil system to enhance crop productivity. Examples of biological products include microbial inoculants and biological control products. For example, a microbial inoculant applied to corn plants will enhance nutrient uptake and increase the plants' nutrient availability (Calvo et al., 2014), resulting in plants with good vigor and good root systems (*Figure 2*). Following the use of the microbial inoculant and improved nutrient uptake, it is expected that nutrient runoff and nutrient leaching will decrease and mineralization/solubilization will improve to benefit the crop. Biocontrol products may be applied directly or indirectly to protect the crop and manage specific pathogens, insects, or weeds.

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Figure 2. A biological product (as a biocontrol or microbial inoculant) may be applied to a corn plant to control disease, influence nutrient uptake, or other processes associated with crop physiology and soil environment.

Purposes of Biological Products

The overall goal of better crop productivity, yield, and resilient agricultural systems is a common theme of biological products but the specific purpose or target of each product varies. Ultimately, it is about each grower's financial investment and income, which depends on crop yield and quality. Four major goals of using biological products in crop production are to manage plant diseases; enhance nutrient uptake and improve crop growth; manage insects and related pests; and manage weeds.

Plant disease management

The most common biological products used in crop disease management are biofungicides, as fungi are the most common pathogens. Some products manage other pathogens such as bacteria and nematodes. More details about this can be found in a NebGuide about biological products for plant disease management, which is part of a series that includes this publication.

Insect management

The goal of biological products in insect management is to reduce pest levels below an economic threshold. Biological control of insects relies on using natural enemies against insect pest species so they can act as population regulators of the species. Microorganisms that are pathogenic to insects are used to suppress pest populations. More information on biological control of insect pests can be found in the Nebraska Extension NebGuide G95–1251, *Biological Control of Insect and Mite Pests* (http://digitalcommons.unl.edu/extensionhist/1176).

Nutrient management

Biostimulants and biofertilizers are biologicals for nutrient management. They are not nutrients but they help solubilize or convert nutrients in the soil into forms available to the crop. Beneficial microorganisms in a biostimulant such as beneficial fungi that have hyphae can spread wider than the crop roots and transfer nutrients to those roots. Also, biologicals help stimulate the plant's natural physiological processes such as root growth in a manner that will result in enhanced nutrient use efficiency. Nutrient enhancers are usually applied as a preplant seed treatment, in-furrow, or as a foliar spray application.

Weed management

Bioherbicides use certain organisms that can suppress the growth of weeds or act as pathogens to kill or hinder the development of weeds and reduce populations. All forms of organisms that can suppress weeds are considered biological control agents of weeds.

Compatibility of Biologicals with Chemicals

Biologicals are important to organic as well as conventional production. They are particularly useful in organic production systems because organic pest management options are limited. In conventional production systems, it is important to emphasize that biologicals are recommended as supplements rather than as replacements for chemicals. Biologicals used in conventional production should be chosen if they are compatible with chemical products that producers are using without significantly increasing input costs.

Biologicals as an IPIM/IPM System Component

Biologicals are more effective when used as a component of integrated pest and input manage-

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ment (IPIM) or integrated pest management (IPM) systems.

Biologicals in IPIM/IPM systems have to be locally adaptable and beneficial to the soil-plant systems. This includes beneficial microorganisms, soil biodiversity, soil structure, and health; enhanced nutrient use efficiency; systemic management of biotic and abiotic stresses; and increased physiological potential. The improved system should lead to better crop productivity. It should confer resiliency and sustainability to the agricultural system in the face of challenges of rapidly changing environmental conditions. The use of biologicals presents these opportunities.

Some growers are concerned about the inconsistency of some biologicals in different environments and soil conditions. Little or no information on the efficacy of some products is another issue. These are legitimate concerns.

As indicated earlier in this publication, some products are not required to be registered or regulated by the EPA; thus, information on their efficacy may not be available. Self-regulation in the industry is helping to alleviate this concern. Specifically, the Biopesticide Industry Alliance, a manufacturers' group, is putting effort into self-regulation to ensure that products maintain quality standards. It also is pushing to improve the biopesticide regulatory process. Additionally, the U.S-based Biostimulant Coalition and the European Biostimulant Industry Council are playing important roles in regulation of biostimulants. Also, as research trials are conducted on the efficacy of biologicals in the state, Nebraska Extension will continue to provide updated information to growers.

Currently, with growing investments and more research in biologicals, EPA regulation, and industry self-regulation, it is believed that efficacy will continue to improve. New technologies, especially the molecular technology of metagenomics, are evolving and helping to understand the complex interactions that occur in soil-plant systems, especially the root microbiome.

Development of the Biological Sector in the Agricultural Industry

People that monitor the agricultural industry have noticed major investments within the last decade in the biological and biorational sectors. Following many acquisitions, realignments, new ventures, and launch of new product platforms, industry analysts have projected that this sector will grow more than 100 percent by 2020. This market direction supports the notion that biological products will play crucial roles in crop production going forward.

Nondiscrimination Statement

Reference to commercial products or trade names is made with the understanding that no discrimination is intended of those not mentioned and no endorsement by Nebraska Extension is implied for those mentioned.

RESOURCES

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