Understanding Pesticides in Organic and Conventional Crop Production Systems

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In conversations about pesticides, certified organic agriculture, conventional production, and backyard gardening, questions are often raised concerning which pesticides can be used, where pesticides come from, and associated risks to people, pollinators, and the environment. Terms like "synthetic," "toxicity," "natural," "organic," and "chemicals" are sometimes used in confusing ways. The goal of this fact sheet is to provide an outline for understanding these and other terms as they relate to pesticides in organic and conventional crop production.

Colorado potato beetle on the left is an example of a pest, while the swallowtail butterfly on the right is an example of a pollinator.

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What Do These Terms Mean?
A **pest** is a destructive or nuisance organism that has a detrimental effect on crops, livestock, food, or human health. For instance, pests such as certain insects, weeds, and pathogens may be found in backyard gardens and crop production systems (NPIC, 2018b). A **pesticide** is a substance that "is intended for preventing, destroying, repelling, or mitigating any pest," according to U.S. federal law (NPIC, 2018a). Pesticides include insecticides, herbicides, fungicides, disinfectants, repellents, and biopesticides. The **toxicity** of a pesticide is its capacity to cause injury to a living system. Toxicity is determined by a substance's chemical makeup. Pesticides may have acute effects over a short period of time, or chronic effects from repeated exposures at lower levels over a longer period of time.

In general, pesticides are most effectively used within an **integrated pest management** (IPM) plan that combines a variety of strategies, such as routinely scouting for pests and using physical barriers like netting. IPM uses tactics that factor in the biology and behavior of the pest, the host plants, and environmental context. Plants that are grown in good soil, receive appropriate amounts of water, and are surrounded by a biodiversity of beneficial insects are likely to be healthier plants and therefore more capable of withstanding minor stress from pest damage (NPIC, 2018b).

The mission of the **Environmental Protection Agency** (EPA) is to protect human health and the environment by developing and enforcing regulations, providing grants, studying environmental issues, sponsoring partnerships, publishing information, and educating the public. The EPA was established in 1970 to consolidate federal research, conduct program monitoring, and establish standards and enforcement to ensure environmental protection. All pesticides are reviewed and registered by the EPA prior to sales and distribution in the United States. In addition to the federal process, each state government has its own review process for new pesticide products. A product approved by the EPA must also be registered in the state.

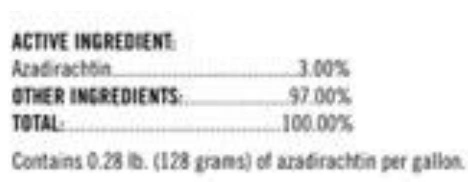
A **chemical** is a basic substance that is used in or produced by a reaction that involves changes to atoms and molecules (Cambridge). All matter is made up of chemicals—the human body, plants, water, air, etc. The word "chemical" is a broad term that is often used to narrowly imply a highly toxic substance. This use of the word can be vague and confusing, as some chemicals are indeed toxic and harmful, while many other chemicals pose no risk and are essential for life.

Types of Pesticides

Synthetic pesticides are compounds produced by people through an industrial process. Many are commercially available to gardeners at retail garden stores, while others are only sold to licensed applicators.

Conventional pesticides are synthetic pesticides typically used in conventional agriculture. As conventional active ingredients are generally produced synthetically, they do not include biopesticides or antimicrobial pesticides.

Naturally occurring pesticides are derived from compounds that are produced in nature, such as diatomaceous earth and biological control agents. In other words, natural pesticides are not synthetic. They tend to break down quickly in the environment, which reduces the risk of harm to non-target organisms but may require repeated applications to affect pests. In general, naturally occurring pesticides tend to be less potent than synthetic pesticides. However, some naturally occurring substances are very toxic to humans and other non-target organisms. For example, arsenic and nicotine sulfate are prohibited in certified organic production and are not registered for use in Ohio in conventional agriculture either due to their toxicity (NPIC, 2017a). Personal protective equipment may be required by the label even for naturally occurring products.



ACTIVE INGREDIENT:	
Azadirachtin	3.00%
OTHER INGREDIENTS:	97.00%
TOTAL:	100.00%

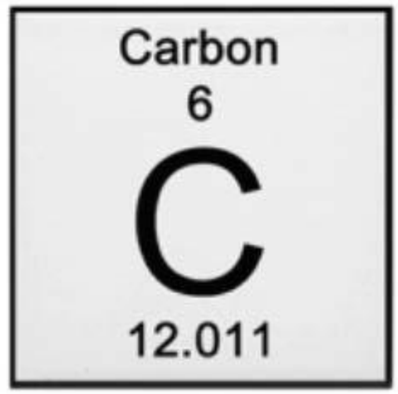
Contains 0.28 lb. (128 grams) of azadirachtin per gallon.

This graphic shows an example of a naturally occurring pesticide. The active ingredient Azadirachtin is a component of neem extract, which is a pesticide that comes from seeds of the neem tree. Active ingredients are listed on the front page of the product label.

Pesticides permitted in certified organic production are certain pesticides that have been approved for use in organic agriculture according to the U.S. Department of Agriculture (USDA). While most of these pesticides are naturally occurring, several approved synthetic materials are available for use under particular circumstances. The USDA compiles the National List of approved and prohibited substances that may be used in organic production. The Organic Materials Review Institute (OMRI) publishes a list of products allowed for use under the USDA National Organic Program. This list is publicly accessible online. An important principle of certified organic production is to attempt to manage pests by alternative means before using approved pesticides.

Most pesticides that are allowed in organic agriculture come from natural origins, not synthetic. For example, pyrethrins are naturally occurring compounds extracted from chrysanthemum plants, while pyrethroids are synthetic compounds that mimic the activity of pyrethrins. The chemical structures of pyrethroids were adapted by scientists from the chemical structures of pyrethrins found in nature. While they operate similarly, pyrethrins are approved for organic agriculture because of their natural origins, while pyrethroids are not.

In the field of chemistry, **organic compounds** are substances that contain the element carbon. Most pesticides, both synthetic and naturally occurring, contain some amount of carbon regardless of their origin. For instance, spinosad is a pesticide derived from a naturally occurring bacteria that contains carbon (NPIC, 2014). Organochlorines are a class of synthetic pesticides including DDT that contain carbon among other elements (NPIC, 1999). As it is such a common component of most pesticides, it can be helpful to remember that the presence of carbon has no implications regarding the safety or origin of a pesticide.



The element carbon is found in both synthetic and naturally occurring pesticides.

Biological control agents are living organisms that are natural enemies of pests. They are used to control pests below damaging thresholds. They can be predators, parasitoids, or pathogens (Barbercheck). Predators such as ladybird beetles catch and eat insect prey. Parasitoids such as certain species of tiny wasps lay their eggs in the host, enabling the larvae to hatch into a food source. Pathogens used as biological control agents cause disease in the target pest.

Biopesticides are derived from natural materials such as plants, animals, bacteria, or certain minerals. There are three categories of biopesticides: biochemical, microbial, and plant-incorporated-protectants. Biochemical pesticides control pests by non-toxic mechanisms such as pheromones that interfere with insect mating. Microbial pesticides contain microorganisms that kill pests, such as the bacterium Bacillus thuringiensis, aka Bt. Plant-incorporated-protectants are pesticidal substances that genetically modified plants are able to produce (EPA). For instance, scientists can take the gene that codes for the pesticidal protein in Bt and transfer it into plant DNA, which allows the plant to make the protein itself.

Often, biopesticides have natural origins, but must be synthesized by people in marketable quantities. Biopesticides are typically less toxic than conventional pesticides. They often degrade quickly in the environment, which can help reduce pollution and exposure issues. Biopesticides tend to target specific pests. In contrast, conventional pesticides often have a broad spectrum of pest activity and can sometimes affect many different non-target organisms.

Biocontrol example is shown by these aphids parasitized by wasps. Photo by Dr. David Shetlar, The Ohio State University.

Reduced risk pesticides are conventional pesticides that can be a useful option for growers who want to decrease risks to human and environmental health. Benefits include: lower use rates, lower impact on human health, lower toxicity to non-target organisms such as birds and fish, less potential for groundwater contamination, and low potential for pesticide resistance development. Once a federally appointed panel confirms that a pesticide warrants reduced risk status, the EPA can accelerate the review and regulatory decision process of conventional pesticides that have a relatively lower risk for human and environmental harm.

Minimal risk pesticides pose little to no risk to the environment or human health as determined by the EPA, so federal pesticide registration is not required. All other types of pesticides must be federally registered. However, minimal risk products do need state registration in Ohio. The active and inert ingredients determine whether a pesticide can be classified as minimum risk. Plant essential oils and corn gluten meal are examples of active ingredients used in minimal risk pesticides.

Regulations that Affect All Pesticides

For all pesticides that are registered in the United States (both synthetic and naturally derived), the EPA has determined that the benefit of using the pesticide exceeds any risks when used according to the pesticide label. Pesticide registration is a legal and scientific process that assesses: the active and inert ingredients of the pesticide; the type of crop it will be applied to; the amount, timing, and frequency of its use; and storage and disposal practices. The evaluation examines human health risks such as cumulative and occupational risks, and environmental risks such as the potential for groundwater contamination and risks to pollinators and endangered species.

Certification of Organic Farms

Organic agriculture is “an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity,” according to the USDA (USDA, 2016). Management practices in organic agriculture typically involve cover crops, biological control, crop rotations, minimal off-farm inputs, and emphasis on biodiversity and sustainability (USDA, 2016). Certified organic production requires a rigorous verification process and third-party annual inspections to ensure thorough adherence to the national standards.

The Organic Materials Review Institute (OMRI) is an international nonprofit organization that determines which products are permitted for use in organic production. The USDA National Organic Program allows OMRI Listed Products for use in certified organic operations. The OMRI Products list is a complete directory of permitted products for organic production and processing. It is available to the public on the OMRI website, and it includes over 5,500 products.

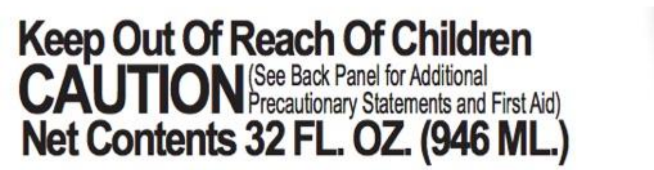
The National Organic Program (NOP) is responsible for developing “rules and regulations for the production, handling, labeling and enforcement of all USDA organic products,” according to the USDA’s website (USDA AMS). The NOP’s process of making the rules for organic agriculture involves input from the National Organic Standards Board as well as the public. The NOP maintains a handbook to help clarify policies and assist organic growers in implementation. When used according to the NOP, OMRI-approved pesticides are not a silver bullet for addressing pest issues. Instead, they can be used as one aspect of a whole-systems approach that must include additional integrated pest management practices, such as crop rotation and strategic crop planting timing.

Understanding Risk

The risk that a pesticide can pose depends on both the toxicity and the exposure (NPIC, 2018c). The toxicity of a pesticide is the capacity of a substance to injure a living organism. The exposure is the amount of pesticide and the length of time that an organism or the environment was subjected to the pesticide—in other words, the dose. Any chemical in large enough amounts can present risks to environmental and human health. In other words, “the dose makes the poison” (NPIC, 2018c). The greater the exposure and the higher the toxicity, the greater the effects of the pesticide. This is called the dose-response relationship.

Look for Signal Words

Regardless of a pesticide’s origin, always read and follow the pesticide label. Pesticide labels are required to have a **signal word**—a word in large print that describes the toxicity of that particular pesticide product. The signal word will be “caution,” “warning,” or “danger” (NPIC, 2018c). **Caution** means low toxicity, **warning** means moderate toxicity, and **danger** means high toxicity. If the EPA has determined that a pesticide is “practically non-toxic,” the product is not required to have a signal word on the label. For more information on toxicity, see the NPIC website for fact sheets about active ingredients: npic.orst.edu/.



Example of the signal word CAUTION found on the front page of a pesticide label.

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