MISSISSIPPI STATE UNIVERSITY EXTENSION

Pesticides: Benefits and Risks

Modern technologies, including the use of pesticides to control insects, weeds, and disease-inducing agents, enables production of food to feed a population predicted to exceed 9.7 billion people by 2050. Starvation and malnutrition in many underdeveloped countries is evidence that populations cannot be sustained when agricultural yields are less than maximum. The *American Heritage Dictionary* defines malnutrition as "suffering from improper nutrition, especially because of insufficient or poorly balanced diet." Without the use of pesticides, food production would be further reduced and the number of individuals suffering from malnutrition would increase.

Changes and Advances

The number of people who produce food has changed dramatically during the past 200 years. In 1787, 90 percent of the United States population lived on farms and produced enough food for themselves and one other person. Mechanization and technological advances in the early 1900s created a need for employees in factories and at manufacturing sites. High wages, combined with less physical labor, attracted laborers from the farm to the factory. Fewer and fewer laborers remained on the farm to plant, cultivate, and harvest crops.

Fortunately, along with this decrease in labor came farm mechanization, which replaced horses with tractors and cultivators. Herbicides replaced garden tools like hoes for weed control. These advancements enabled farmers to grow and manage more acres of crops with the reduced labor force. By 1950, the percentage of individuals who lived on farms had decreased to 16 percent, but those individuals produced enough food for themselves and 27 others.

Not only has the number of farmers decreased, but the total acres of land farmed in the U.S. has also decreased. According to 2022 U.S. Department of Agriculture (USDA) Agricultural Census data, the total acres of land farmed has decreased by 14 percent. However, during this 25-year interval yields of corn increased 36 percent, soybean increased 37 percent, and peanut increased 40 percent.

Identifying Pests

Pests cause major problems and discomfort. A pest can be an annoying or damaging plant or animal. Roaches, wasps, or mice in your house; mosquitoes, ticks, fleas, and fire ants in your yard; the neighbor's cat walking on your car; poison ivy in your flower bed are examples of pests. Unfortunately, pests also invade fields and attack crops cultivated for food and fiber. Large acreages of the same crops or high concentrations of food-producing animals in a limited area favor buildup of insects, diseases, and certain weeds. These pests must be controlled if usable food and fiber products are to be produced. For example, there are 80,000 to 100,000 diseases; 3,000 species of nematodes; 10,000 species of insects; and 1,800 species of weeds that damage the crop production process.

It has been estimated that insects, diseases, and weeds destroy approximately one-third of the world's food supply, even with using the most current pest management technology. Losses without this technology could soar to 60 to 80 percent. Similar to when a person becomes ill, the doctor must first diagnose the cause of the illness to determine a treatment strategy. A parallel tactic exists for pest management, regardless of whether the pest is an insect, disease, or weed. While many weeds are less mobile compared to insects and plant pathogens, sufficient labor does not exist to manually weed every acre of crop from emergence through harvest. The conditions for that type of employment are not favorable. Manual control of insects and diseases is impossible due to the mobility of these pests.

Therefore, the first step toward successful pest management is the identification of the pest. Numerous resources exist to aid with identification, whether online, crop consultant, reference books, county Extension agents. And like the proper medicine can be prescribed to a person once the cause of illness is determined, a proven management strategy can be prescribed once the pest has been identified.

Use of Pesticides

For many years, pesticides have been used in conjunction with host-plant resistance and cultural, mechanical, and biological tactics in an integrated pest management system to combat the battle against destructive pests. Pesticides are chemicals that are used to control pests, especially insects and rodents. Pesticides may be naturally occurring substances or synthetic.

Pesticides can be toxic to people, animals, and plants if improperly used. Several early insecticides and fungicides contained highly toxic heavy metals such as arsenic, copper, lead, and mercury, or other toxic compounds such as nicotine. Many of these early pesticides, either because of the active ingredient (ingredient that makes the pesticide work) or the type of formulation (how the chemicals are mixed together), were highly toxic to pests and also to those individuals applying the pesticides.

Most of these early pesticides are no longer approved for use. We may be exposed to toxic compounds regularly. Salt, caffeine, aspirin, alcohol, gasoline, even water, can be toxic. We can reduce the risk of a toxic effect if we minimize our exposure to those hazards.

Control Guidelines

Fortunately, advances and developments in the agrichemical industry have turned out modern pesticides that are much less toxic to the applicator and environment but still control the pests that damage crops, livestock, forests, and homes. Most of these pesticides are organic (carbon-containing) compounds. Many people are frightened by pesticides and thoughts of pesticide residues in food supplies. However, there are strict regulations governing manufacturers and users of pesticides.

Most people are not aware of the testing required by the Environmental Protection Agency (EPA) to ensure the safety of a pesticide before that product can be used. As with most areas of life, there is always room for improvement. Although the registration requirements set forth by the EPA are the most stringent in the world, these requirements must continually be reevaluated and improved.

An example of a product removed from the market after reevaluation is dichlorodiphenyltrichloroethane (DDT). DDT was the one of the first synthetic insecticides widely used for insect control. Because of the wide spectrum of insects controlled and the length of time it controlled those insects, DDT was widely used. It is credited for the control of human diseases such as malaria, dengue, trench fever, plague, louse-borne typhus, dysentery and diarrhea, yaws, and many other diseases carried by insects. It has been estimated that the lives of at least 5 million people have been saved and more than 100 million illnesses have been prevented by the use of DDT.

However, DDT possessed certain chemical characteristics that were not desirable to many organisms in the environment. Many characteristics that had not been considered necessary for pesticide registration when DDT was approved appeared essential to avoid damage to the environment. Therefore, registration of DDT for use in the U.S. was canceled.

Evaluations

Before registration, all pesticides must be proven to be within established and approved guidelines of safety to the environment, people, and animals. The EPA evaluates the toxicity of the pesticide and its residues, the ecological effects of using that product, and the effects of environmental and applicator exposure to the product, including carcinogenicity (the ability to induce cancer) with prolonged exposure. This information is gathered to determine whether or not use of the product will create unreasonable risks to the environment, other organisms, or people. If use of the pesticide does pose unnecessary risk, registration is not granted, or the EPA may require restrictions on the label to reduce the chances of damage. If these risks cannot be reduced, registration is not granted.

Pesticides are evaluated for potential to cause immediate harm to people through ingestion (eating), contact with skin, breathing fumes, or spills in the eyes. Harm from exposure to low doses over a long period of time is also examined. Pesticides are evaluated for potential to cause birth defects, cancer, reproduction problems, and mutations. Only after the potential pesticide has been determined to be within the allowable, established limits of risk, is the registration process continued. The evaluation criteria for pesticide safety are continually improved and updated to provide greater margins of safety. Every pesticide must be periodically re-evaluated by EPA to determine if use still meets the updated safety guidelines.

Tolerances

Tolerances are maximum legal limits of pesticide residues that can occur in food and are normally set 100 times below the level that might cause harm. Pesticide tolerances are set by the EPA and enforced by the Food and Drug Administration (FDA). The FDA samples foods, whether produced in the U.S. or imported, to monitor pesticide residues. Produce or crops that contain above-tolerance pesticide residues or residues of products banned from sales in the U.S. cannot be sold. Since each and every food item cannot be tested for pesticide residues, subsamples of larger volumes of food are selected. Samples are pulled at random to ensure all have an equal chance of selection for testing.

Before testing, food items are prepared for consumption, and subsamples are tested for residue analysis. Risk assessment is how the EPA determines tolerances. Based on individual food consumption data, the EPA determines the amount of residues ingested (or exposure) by the average individual. Exposure multiplied by the toxicity gives the risk. The process for evaluating new pesticides must be changed as new technology and safety evaluation procedures are developed.

There is an ongoing process to reevaluate the safety of pesticides that were registered before November 1, 1984. More than 103,000 pesticide products have been registered. This includes not only herbicides, fungicides, and insecticides, but also rodenticides, algacides, antimicrobial products, bacteriacides, viricides, and inert ingredients. Pesticide manufacturers must evaluate the costs of reregistration versus the potential for sales. Many products presently considered safe will not be reregistered because the market share is small and the cost of reregistration is not cost effective.

Pesticides and Foods

Some pesticide residues do occur in foods people eat. The EPA has evaluated the risks of consumption of these residues and concluded that, based on prolonged exposure to the expected doses, no harm will result from consumption. Some individuals insist no pesticide residues should be allowed in foods. This appears to be based primarily on fear of carcinogenicity of these compounds, a fear refuted by many. Authors Bruce Ames and Leonard Gold acknowledged the carcinogenic activity of some synthetic pesticides in rodent tests of maximum-tolerated dose but stated, "an astounding percentage of chemicals tested in animal cancer tests are being classified as carcinogens (over 50 percent), and most of these do not appear to be damaging to DNA." They cite evidence that frequent damage to DNA by chemicals causing mutations may cause cancer.

They reported, "There are large numbers of mutagens and carcinogens in every meal, all perfectly natural and traditional..." Potential carcinogens in food from plants are overwhelmingly naturally produced by the plant, or chemicals resulting from cooking. Residues of pesticides are minor. The assumption that all synthetic chemical residues in food are dangerous, and that all natural substances are not dangerous, has been refuted by others.

More than 400 years ago, Paracelsus drew the conclusion that the dose of a toxin made the substance poisonous. He also concluded all substances could be toxic if large enough quantities were consumed. Alice Ottoboni reiterated this in the title of her book *The Dose Makes the Poison*. Our bodies are capable of removing small quantities of substances that would be toxic at high levels.

Responsible Use

Responsible use of pesticides includes every attempt to protect the environment, including water supplies. Documented contaminations of groundwater have most often been due to contamination at sources of pesticide mixing for application—at wellheads. Strict adherence to regulations and common-sense practices are necessary to prevent this occurrence. Programs for proper disposal of pesticide containers are essential. A program for recycling empty pesticide containers and containers of unknown pesticides occurs in Mississippi and other states.

Pesticide use throughout the world has increased since the 1940s; however, the average life expectancy has also increased. In 1950, the average life span in the U.S. was 68 years. By 1970, that U.S. resident expected to live 70.5 years, and by 1990, almost 75 years. It is necessary for all who manufacture and use pesticides to ensure safe and responsible use. It is also necessary for the general public to become knowledgeable about the benefits and risks of using pesticide. With present technology, the world population cannot be fed without use of agricultural chemicals, including pesticides.

References

Ames, B. N., & Gold, L. S. (1988). Carcinogenic risk estimation. *Science, 240*, 1045–1047.

Chambers, J. E. (1992). Insecticide toxicity and future research needs. In Proceedings, 2nd Princess Chulabhorn Science Congress on Environment, Science and Technology: The Challenge of the 21st Century (pp. 2-6).

Davies, P. (Ed.). (1979). *The American heritage dictionary of the English language*. Dell Publishing Co., Inc.

Monsanto Company. (1991). The food equation: Feeding a growing global family [Video]. In cooperation with the National Corn Growers Association, the W. J. Morse Foundation, and the American Soybean Association. Monsanto Detail Program.

ICI Americas, Inc. (1989). Food, pesticides, and the question of risk.

Jukes, T. H. (1963). People and pesticides. *American Scientist*, *51*(3): 355–361.

Knipling, E. F. (1953). The greater hazard—Insects or insecticides. *Journal of Economic Entomology, 46*, 1–7.

Ottoboni, M. A. (1984). The dose makes the poison (p. 22). Vincent Books

Vilsack, T., Jacobs-Young, C., & Hamer, H. (2022). 2022 Census of Agriculture. United States Department of Agriculture National Agricultural Statistics Service.

Publication 1962 (POD-01-25)

By **John D. Byrd Jr.**, PhD, Extension/Research Professor, Plant and Soil Sciences; **David R. Shaw**, PhD, former Professor and Director, GeoResources Institute; and Eric P. Webster, former Research Assistant, Plant and Soil Sciences.