Pesticide Usage in the United States: History, Benefits, Risks, and Trends

The Growing Human Population and Pesticides

Humans are among the most successful living things on Earth. In just a few thousand years, we have colonized every continent, adapted to nearly every type of habitat, and, in biblical terms, multiplied and filled all the Earth.

Much of this success is traced to our ability to solve problems and change habitats to suit our purposes. For instance, warm clothing and constructed shelters let us live in cold climates that would otherwise kill us. We coax high productivity through the breeding and management of food plants and animals. Through knowledge and technology, we control diseases, fungi, weeds, nematodes, insects, birds, rodents, and other pests that would otherwise shorten our lives or compete with us for food.

However, no species enjoys unlimited population growth. All living things are limited by their resources, disease, or natural disasters. Man is no exception. Some wonder if our natural resources can sustain the soaring human population. Until human population growth stabilizes, and it probably will not until the middle of the next century, [1] we must use our natural resources efficiently.

Pesticides are one tool that lets us do that. In fact, the abundant food and high standard of living we enjoy in the United States would not be possible without pesticides. However, many people today think that pesticides are unacceptably dangerous to the environment or to man. Citizens want to know more about pesticides, their benefits, their risks, and the ways government regulates them. With good information, citizens are better able to analyze the arguments of both opponents and supporters of pesticide use. Pesticide policies should be formulated based on facts and reason instead of false perceptions and hysteria.

Any rational approach to pesticide use should include a risk-benefit comparison. Pesticides, by nature, are risky, but their benefits are real and easily taken for granted. For example, some people want a total ban of pesticides, but they must be ready to accept termites in their houses, fleas in their carpets, moldy vegetables, food-borne toxins, food shortages with soaring prices, and outbreaks of long-forgotten diseases.

But what about the risks of pesticides? Pesticides are poisons and can be hazardous. Fortunately, research, education, and government agencies are constantly reducing the risk of using pesticides by producing “safer” chemicals, pest-specific pesticides, better application methods, and tougher pesticide laws. The result is a constantly improving risk-benefit ratio. But that does not mean the job is complete. Misuse of and accidents involving pesticides still occur. And even when used correctly, some pesticides can harm the environment and non-targeted living things. Just as the benefits of pesticides are real, so are the risks. There will always be room for improved pest control methods.

The purpose of this publication is to explain the nature of pesticides, their history, their benefits, their risks, the regulations in place to ensure their responsible use, and current trends in their use.

What are Pesticides?

In nature, there are no pests. Humans label as “pests” any plants or animals that endanger our food supply, health, or comfort. To manage these pests we have “pesticides”. These are products “intended for preventing, destroying, repelling, or mitigating any pest.”[2]

The major classes of pesticides are as follows:

Type of Pesticide	Target Pest Group
Acaricide	Mites, ticks, spiders
Antimicrobial	Bacteria, viruses, other microbes
Attractant	Attracts pests for monitoring or killing
Avicide	Birds
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects
Molluscicide	Snails and slugs
Nematicide	Nematodes
Piscicide	Fish
Predacide	Vertebrate predators
Repellent	Repels pests
Rodenticide	Rodents
Synergist	Improves performance of another pesticide

In the United States, pesticides are used on 900,000 farms and in 70 million households. Herbicides are the most widely used type of pesticide. Agriculture uses 75% of all pesticides,[3] but 85% of all U.S. households have at least one pesticide in storage, and 63% have one to five stored.[4] A Minnesota survey [5] found that on a per-acre basis urban dwellers use herbicides for lawn care at rates equal to those used by farmers for food production.

Historical Developments with Pesticides

Pesticides are not new. Ancient Romans killed insect pests by burning sulfur and controlled weeds with salt. In the 1600s, ants were controlled with mixtures of honey and arsenic. By the late nineteenth century, U.S. farmers were using copper acetoarsenite (Paris green), calcium arsenate, nicotine sulfate, and sulfur to control insect pests in field crops, but often results were unsatisfactory because of the primitive chemistry and application methods.

An emergence in pesticide use began after World War II with the introduction of DDT, BHC, aldrin, dieldrin, endrin, and 2,4-D. These new chemicals were inexpensive, effective, and enormously popular. DDT was especially favored for its broad-spectrum activity against insect pests of agriculture and human health. 2,4-D was an inexpensive and effective way to control weeds in grass crops such as corn. Lulled into a false sense of security, users applied pesticides liberally in pursuit of habitats “sterilized” of pests. Under constant chemical pressure, some pests became genetically resistant to pesticides, non-target plants and animals were harmed, and pesticide residues appeared in unexpected places. With the publication of Rachel Carson’s book *Silent Spring* [6] in 1962, public confidence in pesticide use was shaken. Carson painted a grim picture of environmental consequences of careless pesticide use. Although the quality of her reporting has been severely criticized, Carson, more than anyone before, pointed out the risks of pesticides.

The result has been a redirection of research toward more pest-specific pesticides and cropping methods that reduce reliance on pesticides. Many of today’s pesticides are designed after “natural” pesticides. For example, “pyrethroid” insecticides are modeled after “pyrethrins,” which are natural, plant-derived poisons that have been used as insecticides for hundreds of years. “Insect growth regulators” (IGRs) mimic hormones that affect insect growth, but they have little effect on non-target animals. These products and similar ones using bacteria, viruses, or other natural pest control agents are called “biorational” pesticides.

In the 1960s, researchers began developing a different approach to pest control called “integrated pest management” (IPM). IPM aims to keep pests at economically insignificant levels by using crop production methods that discourage pests, encouraging beneficial predators or parasites that attack pests, and timing pesticide applications to coincide with the most susceptible period of the pest’s life cycle. IPM assumes that certain low levels of pests are tolerable. Eradication is not necessarily a goal or even desirable in some cases because the elimination of a pest may also result in the loss of the beneficial predators or parasites that need the pest in order to survive. IPM rarely is a substitute for using pesticides; rather, it is more often used to improve the effectiveness or reduce the overall use of pesticides.

However, even with IPM, pesticides frequently are the only way to deal with emergency pest outbreaks. Also, in some situations any level of a pest is intolerable. For example, most people would consider even one rat in their house intolerable. Along this same line, most shoppers do not buy fruit or vegetables with blemishes from plant diseases or insects. Because of this consumer bias, farmers cannot afford to produce foods with even minor signs of pest damage, so they are forced to use pesticides.

The Benefits of Pesticides

Some of the best studies of the benefits of pesticides have estimated the economic consequences of a ban on pesticide use. These "what if?" studies deal with extreme-case possibilities, but serve as a starting point for putting pesticides in perspective.

A study by Knutson and others[7] describes possible effects on U.S. society of a hypothetical ban of herbicides, insecticides, and fungicides. Without pesticides, U.S. food production would drop and food prices would soar. With lower production and higher prices, U.S. farmers would be less competitive in global markets for major grains, cotton, and peanuts. U.S. exports of corn, wheat, and soybeans would drop 27 percent, with a loss of 132,000 jobs. A pesticide ban in the U.S. would decrease year-ending supplies of corn, wheat, and soybeans 73 percent, trigger price instability, slow U.S. food aid programs to poor countries, and increase worldwide hunger.

The suggestion that a ban on pesticide use would help the environment may not be true. Under a pesticide ban, the number of farmed acres would have to be increased to make up for reduced per-acre yields, which would in turn cause widespread loss of wildlife habitat. Without herbicides, farmers would probably have to cultivate fields more frequently to control weeds, which would lead to increased soil loss from erosion. Other countries, many with lower standards of environmental concern than ours, would increase pesticide use to boost crop production and take advantage of reduced U.S. food exports.

Effects on U.S. farmers would vary. Incomes of food plant growers would more than double, but most of this increase would be offset by new land purchases because growers would need to cultivate more land to make up for lower yields. Incomes of livestock producers would drop 50 percent because of higher feed prices. Without pesticides, southern farmers would fare worse than their northern counterparts because southern climates promote higher pest populations.

A second study[8] focused only on the consequences of a fungicide ban. These chemicals control plant disease fungi that, if unchecked, kill crop plants and sometimes produce lethal natural food poisons. A U.S. ban on fungicides would reduce production of fruit 32 percent, vegetables 21 percent, peanuts 68 percent, and corn and wheat 6 percent each. These figures are even more grim when we consider that the consumption of fruits and vegetables help prevent heart disease and some cancers.[9] Without fungicides, per capita consumption of these healthy foods would decrease 24 percent, with negative consequences for our nation's health.

A ban on fungicides would increase consumer food prices by 13 percent, reduce the gross national product by about $28 billion, reduce total personal spending by $22 billion, and eliminate 235,000 jobs — including 125,000 jobs in the farm sector which represents 4 percent of total agricultural employment.

A fungicide ban would have the greatest economic and health impacts on the poor because these groups spend a higher percentage of their incomes on food. For example, the annual food bill for a family at the poverty level would increase $362, which is 3 percent of their yearly income. Because of higher prices and lower production of fruits and vegetables, consumption of these healthy foods would shrink most among the nation's poor, forcing this group to bear the greatest health consequences of a deteriorating U.S. diet.

But even without these "what if?" studies the benefits of pesticides are obvious. Using carefully timed pesticide applications, farmers have nearly eradicated the cotton boll weevil in large areas of the southeast; this pest devastated the cotton-based southern farm economy at the beginning of the twentieth century. Worldwide, herbicides have provided a 10 to 20 percent yield increase in bread grains, enough for fifteen loaves of bread for each person on the earth.[10] In the poorest countries, 95 percent of the population produces the food to feed itself and the remaining 5 percent. Whereas in developed countries the reverse is true; 3 to 5 percent of the population produces enough to feed the rest, in addition to exporting the surplus.[11] This incredible efficiency in food production in the developed countries would not be possible without pesticides.

The value of pesticides goes beyond agriculture. Many tick-and insect-borne diseases—yellow fever, encephalitis, plague, typhoid fever, malaria, dog heartworms, and Rocky Mountain spotted fever—today are held in check by insecticides. By controlling fleas, cockroaches, and flies, insecticides improve the sanitation and comfort of our homes. Long-lasting soil pesticides protect millions of U. S. homes against termites.

Sometimes pesticides can restore balance to ecosystems harmed by the invasion of exotic species. For example, the sea lamprey, a parasitic eel, invaded the Great Lakes after a shipping canal around Niagara

Falls was built in 1829. The eels attacked native species of fish, and by the 1950s populations of lake trout were decimated. The pesticide TFM was used to control the lamprey, and today the lake trout population is recovering.

Where would the United States be without pesticides? These chemicals improve food quality, quantity, and variety. They improve human health by controlling natural food poisons, increasing production of fruits and vegetables, and helping to control long-forgotten diseases. They protect our homes and property. They let U.S. farmers compete profitably in an increasingly global economy. Truly, the standard of living we take for granted in the United States would not be possible without the benefits of pesticides.

Understanding Pesticide Risks

To deal with pesticides responsibly, we must balance their benefits with their risks. But therein lies the conflict between pesticide supporters and opponents, because benefits and risks are rarely measured with the same "currency." Benefits are usually measured in economic terms, whereas risks are measured in terms of human and environmental health. People differ in the priorities they give these two factors. In the worst case, this means opposing groups compare dollars and human lives. In the best case, groups are forced to seek solutions that are both environmentally wise and economically realistic.

In the United States, the Environmental Protection Agency (EPA) regulates pesticides. All pesticides used must be registered with the EPA, and the agency requires a battery of scientific tests not only for every pesticide, but for every use of every pesticide. Costs for this research must be borne by the company, or registrant, that hopes to sell the product. The registrant must provide data on a pesticide's toxicity, its risks to humans, and its effects on the environment. Many pesticide uses are dropped by prospective registrants who decide that the market for a certain pesticide does not justify the costs of meeting the EPA's data requirements for registration.

Pesticides are designed to be toxic to living things, so by their very nature they pose risks. The risk of a substance is a function of the substance's toxicity and the amount of exposure to that substance. In the words of the ancient adage, "the dose makes the poison."

Toxic substances can enter the body through the skin, mouth, eyes, or lungs. There are two types of toxicity: 1) "acute toxicity" or toxic effects resulting from a short exposure to a substance, and 2) "chronic toxicity" or toxic effects resulting after a long exposure (up to several years).

To help us understand the acute toxicity of a substance, scientists use a measure termed the LD_{50}, which is the Lethal Dose needed to kill 50 percent of laboratory test animals (usually measured as milligrams of poison per kilogram body weight). The smaller the LD_{50}, the more dangerous the poison. LD_{50}s are generated for many test animals and pests. Remember that any substance can be toxic at a sufficiently high dose. The LD_{50} of ordinary table salt is 3 grams per kilogram body weight; a lethal dose of table salt for a small child is about two tablespoons.

These abbreviations are confusing, and laypeople can not be expected to interpret LD_{50}s. Therefore, scientists have grouped pesticides with similar LD_{50}s into four categories. Each category has a "signal word" which by law must appear on the pesticide product label to inform buyers of the acute toxicity of the product.

Chronic or long-term risk from pesticides is more difficult to measure because it depends on the substance, length of exposure, dose, and genetic and/or life-style differences among the organisms involved. Because of its slow and uncertain effects, chronic toxicity seems to be of the most concern to people.

Public concern about chronic pesticide risk has been enhanced by advances in technology. In the 1950s, trace amounts of substances could be detected at one part per million; anything below this level was considered zero. By 1965, we could detect one part per billion. By 1975, it was one part per trillion, and today we are reaching toward one part per quadrillion. (To put these numbers in perspective, one part per trillion equals one grain of salt in an Olympic-sized swimming pool.) A true zero is becoming more difficult to find.

After decades of pesticide use in the United States, it is understandable that pesticide residues show up almost anywhere we look for them. With our advanced detection equipment, the question is not whether pesticide residues occur in our food, air, or water, but rather in what amounts do they occur. Because we can detect a pesticide at one part per 1,000,000,000,000, does that mean it is toxicologically relevant?

Recognizing the importance of pesticides and our sensitive residue detection abilities, the EPA has established maximum allowable residue levels, called "tolerances," for thousands of crop and pesticide combinations. This means that certain pesticide residues on our food are legal and within the EPA's range of "acceptable" risk. The EPA has gone to great lengths to make the tolerances conservative.

Let's assume a company asks the EPA to set a tolerance for a pesticide on watermelon. First, the EPA requires the company to provide data on the pesticide residues on watermelon that result from the maximum allowable application rate of the pesticide in question, the maximum allowable number of applications, and the minimum time between application and harvest. These are worst-case situations that rarely occur.

The EPA also requires the company to perform toxicity tests on laboratory animals to find the No Observable Effect Level (NOEL) for the pesticide, which is the dose at which no effects are detected. The NOEL is then divided by 100 to 1000 to arrive at an Acceptable Daily Intake (ADI) or Reference Dose (RfD), which is considered the daily intake level a person can consume during an average lifetime without significant risk health.

Using government data, the EPA then calculates how many watermelons are consumed each year. The agency conservatively assumes that every watermelon is treated with the pesticide in question and at the highest (worst-case) level. It calculates a projected daily intake level of the pesticide resulting from consuming watermelons.

Finally, the EPA looks at the residues of the pesticide already resulting from its use on all other crops. After adding the amount contributed by watermelons, if the total human exposure to pesticide is still below the ADI, the Agency will grant a tolerance that defines the maximum residue of the pesticide allowable on watermelons.

A pesticide can be legally used on a food crop only if the EPA has granted a tolerance for that use. So, when label instructions for applying the product are followed exactly, residues on treated crops at harvest are below tolerance. Finally, these already low levels are reduced again by washing, peeling, and cooking.

Studies have consistently shown that pesticide levels on food are low. Food items were collected from grocery stores in thirteen cities in the United States over ten months and analyzed for residues of certain fungicides.[12] Of 5,888 food items, 91 percent had no detectable levels of these fungicides. The samples were not washed or peeled before analysis, so even the detected levels were higher than a normal consumer would encounter at the table. In a New Jersey study,[13] 225 food samples composed of apples, lettuce, peaches, peppers, potatoes, snap beans, spinach, sweet corn, and tomatoes were analyzed for residues from 26 pesticides, 15 of which are classed by EPA as possibly causing cancer. About half the samples came from other countries or from other states, whereas the rest were fresh produce grown on New Jersey farms. In no case were any residues detected above EPA tolerances.

The U.S. Food and Drug Administration (FDA) routinely samples around 12,000 grocery store food items each year for pesticide residues.[14] In many cases, food items are prepared table-ready before they are analyzed so that data reflect residue levels actually eaten by consumers. In 1987, the FDA analyzed 14,492 samples of domestically produced food and food imported from 79 countries. Fifty percent of the samples had no detectable residues, and less than 1 percent had levels exceeding legal tolerances. In general, dietary intake of pesticides for the average American is a mere fraction of the acceptable daily intake — a level already well below doses known to cause risk. Our food in America is safe!

Finally, the EPA decides the environmental consequences of a proposed pesticide use. The registrant provides data on a pesticide's movement in soil, water, and air. With these data, the EPA evaluates whether the product poses unreasonable environmental risks. The EPA seriously considers the environmental effects of a pesticide, even to the point of weighing them against human risk. For example, a popular insecticide used on corn was canceled because the EPA decided it posed an unacceptable risk to birds even though its replacement is slightly more hazardous to humans.[15]

Current Trends in Pesticide Usage

In the face of a growing human population and increased urbanization, the demand for pesticides will only rise. Farmers must increase yields on increasingly fewer farm acres. Poorer countries will not sustain more people without first controlling pest-borne diseases. Citizens of developed countries, accustomed to high standards of living, will continue to demand inexpensive, high-quality food, freedom from pest-borne diseases, and pest-free homes.

However, the risks of pesticides, whether real or perceived, may force changes in the way these chemicals are used. Scientists and lawmakers are working toward pest control plans that are environmentally sound, effective, and profitable. The best pesticide policies will reconcile environmental concerns with economic realities. Pests must be managed, and farmers must survive economically.

IPM methods will continue to reduce our reliance on synthetic pesticides. IPM has always implied that pesticides are one of many weapons in the pest control arsenal which includes genetics, biologic controls, and plant production practices. IPM has research and "real life" success stories to keep it in the forefront of pest control. IPM is here to stay!

That does not mean that IPM will not be redefined or adopt new methods as knowledge in the area of pest management increases. Already there are new concepts and buzzwords (i.e., "low input" agriculture and "sustainable" agriculture) which are basically IPM methods with slightly different approaches or emphases.

IPM or related methods will not eliminate the need for pesticides. The benefits of pesticides are real, and this reality will outlive the changeable winds of public opinion. Pesticides can give fast and adequate relief from pests. As the human population grows and farm acreage shrinks, food production efficiency cannot be jeopardized. We will need all of the tools at our disposal for food production, including pesticides.

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