Fertilizers are chemicals used to make the soil produce more plants. They contain reused plant and animal waste—such as manure—or a mixture of chemicals made by humans. Unfortunately, many farmers and gardeners use too much fertilizer, and the excess pollutes the environment, sometimes causing health problems for humans and animals.

Among the many chemicals present in fertilizers, three are critical for plant growth: nitrogen, phosphorus, and potassium. Of those three, nitrogen has caused the most damage to the environment. When released into the environment, nitrogen from fertilizers forms compounds that can contribute to our changing climate and create conditions that kill fish and other marine life.

What can we do about it? Decreasing fertilizer waste is a large part of the solution, and this means taking a closer look at how we grow our food. Some scientists advocate growing food on small local farms instead of large industrial farms. This way, it is easier to control the amount of nitrogen used by plants. Other scientists are growing new crops that live for 3 or more years instead of the more common crops that live only 1 year.

Fertilizers and the nitrogen cycle

It is perhaps surprising that plants would need an additional source of nitrogen, since almost 80% of the air consists of nitrogen. But the nitrogen in the air is in the form of N₂ molecules, which react very little and cannot be used by plants to grow. Instead, fertilizers provide a form of nitrogen that plants can use, called “fixed” nitrogen.

There are exceptions, though. Some plants, such as soybeans, peas, and clover, can use nitrogen from the air. That’s because they have symbiotic bacteria growing in their roots. These bacteria have the unusual ability to convert atmospheric nitrogen (N₂) into a chemically usable form.

What happens when we spread fertilizer on soil? The nitrogen from the fertilizer is taken up by plants to help them grow. But if too much nitrogen is present—which is what happens when too much fertilizer is used—some of this nitrogen does not return to the atmosphere and contributes to environmental pollution instead.

The way nitrogen is used by plants and returned to the environment is part of a natural cycle called the nitrogen cycle (Fig. 1). To understand how it works, let’s look at how nitrogen is absorbed by plants.

In soil or in a fertilizer, nitrogen is in the form of either ammonia (NH₃) or the ammonium ion (NH₄⁺). Bacteria and fungi present in the soil convert ammonia into ammonium ions. Then, soil bacteria of the Nitrosomonas species convert the ammonium ions into nitrite ions (NO₂⁻), which are further con-
Organic Farming

Adam Barr holding Daikon radishes.

To reduce pollution from nitrogen compounds that come from fertilizers, some farmers advocate using only naturally occurring fertilizers—animal manure, decomposed plant and animal material called compost, and a type of vegetation called green manure. These farmers don’t use fertilizers that contain synthetic chemicals or minerals because these fertilizers release more nitrogen in the environment than naturally occurring fertilizers.

Organic farming has grown over the years. In 2007, it was a $46 billion industry, with about 32 million hectares (80 million acres) farmed organically worldwide.

Adam Barr is an organic farmer who owns a seventh generation family farm in Meade County, Ky., about an hour outside of Louisville. Barr and his family don’t use synthetic fertilizers to raise vegetables, beef, and chicken.

Wearing a wide-brimmed hat, Barr leans against the back of his truck that serves as a farm stand at a local market. He sells onions, carrots, and meat. He also distributes boxes of fresh vegetables to customers who subscribe to a program called Community-Supported Agriculture. Through this program, people sign up at the beginning of the season and pay an upfront fee. Then, each week during the growing season, they pick up their week’s worth of produce. Barr’s customers buy fresh vegetables at better than retail price, while experiencing the ups and downs of the growing season.

Organic farmers ensure that nitrogen is present in the soil for plant growth and does not leach out. In the chicken house at Barr Farms, sawdust is spread over the floor to trap and stabilize nitrogen from the chicken waste. The carbon-based layer of sawdust traps the ammonia and prevents it from leaking in the air. A fine layer of sawdust is spread on the fields in the spring to provide a nitrogen boost.

For Barr, growing food means understanding the cycles of plant and animal life. “Life and death are two ends of the same loop,” he says. “You see what’s naturally happening with livestock and plants and it is about getting them to work in concert.”

—Beth Nolte

Excess fertilizer = Damage to the Environment

When too much fertilizer is applied to the soil, the excess leaches into groundwater and runs off into rivers and lakes, and ultimately into oceans, where it can cause trouble for marine life. First, nitrates from the fertilizer help algae grow more than usual. Then, when these algae die, they fall to the bottom of the ocean and are decomposed by bacteria. To do so, the bacteria use oxygen dissolved in the water. When the number of dead algae is larger than normal, the bacteria can use up all of the oxygen present in water and, as a result, fish and other marine life cannot breathe, and they die.

Nitrates from fertilizers can also be converted into nitrous oxide (N₂O), which is released into the air. This gas contributes to global climate change and reduces the amount of ozone (O₃) present in the stratosphere.

Ozone is a chemical that absorbs much of the harmful ultraviolet radiation that comes from the sun. The stratosphere is a layer of the atmosphere located at altitudes between 6 miles and 30 miles above the Earth’s surface.
How bad is the situation? James Galloway, environmental science professor at the University of Virginia in Charlottesville says that because plants and animals do not use nitrogen efficiently, only 10%–15% of the nitrogen actually ends up in the food we consume. The rest is washed away into rivers and lakes.

Worldwide, the amount of nitrogen wasted in the environment is even larger. In 1990, fertilizers provided 110 billion kilograms of nitrogen for the production of food. The human body requires only about 2 kilograms per year of nitrogen in food, so with a world population of 5.3 billion people in 1990, only about 10 billion kilograms was needed.

Not only is nitrogen from fertilizers released in lakes and rivers or in the air, but it can also deposit from the air to the Earth’s surface, where it can further pollute the environment. The amount of nitrogen deposited annually from the air to the Earth’s surface worldwide is shown in Fig. 2.

Small farms versus big farms

Do large industrial farms cause more nitrogen pollution than small farms? Studies by the U.S. Environmental Protection Agency have shown that this is indeed the case.

The other problem is that in an effort to get rid of the waste, too much is applied to agricultural fields. The overload gets washed into aquatic systems. Some scientists note that these problems don’t happen on small farms, where the amount of animal waste is easier to manage.

Long-living crops

Every year, farmers sow seeds, wait for crops to grow, and then harvest them. But in the future, all this may change. Scientists at the Land Institute in Salina, Kan., are breeding new crops that would live for many years. This way, farmers would not have to grow them again every year and, as a result, would use less fertilizer.

Plants that can live for years on end are called perennials. Most crops, however, live only for one growing season and are thus called annuals. By breeding annual crops with their perennial relatives, the scientists at the Land Institute have created plants that have the best of both—the high productivity of an annual in a long-living perennial. The hope is to create perennial wheat, corn, sorghum, and sunflower.

If that happens, it would be a huge achievement! It would change the process of farming as we know it. New hybrid perennial plants would have more developed roots than annual crops, creating a niche for microorganisms to live and create healthy soil.

Jerry Glover, an agroecologist at the Land Institute, and colleagues predict that it will be possible to grow perennial crops within the next 25–50 years. While this is far into the future, it offers a good option to reduce fertilizer waste and to increase crop yields.

SELECTED REFERENCES


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