Study highlights massive imbalances in global fertilizer use

June 22 2009, BY MARK SHWARTZ

A comparison of 3 corn-growing areas of the world found massive imbalances in fertilizer use, resulting in malnourishment in some regions and pollution in others.

(PhysOrg.com) -- Synthetic fertilizers have dramatically increased food production worldwide. But the unintended costs to the environment and human health have been substantial. Nitrogen runoff from farms has contaminated surface and groundwater and helped create massive “dead zones” in coastal areas, such as the Gulf of Mexico. And ammonia from fertilized cropland has become a major source of air pollution, while emissions of nitrous oxide form a potent greenhouse gas.

These and other negative environmental impacts have led some researchers and policymakers to call for reductions in the use of synthetic fertilizers. But in a report published in the June 19 issue of the

journal Science, an international team of ecologists and agricultural experts warns against a “one-size-fits-all” approach to managing global food production.

“Most agricultural systems follow a trajectory from too little in the way of added nutrients to too much, and both extremes have substantial human and environmental costs,” said lead author Peter Vitousek, a professor of biology at Stanford University and senior fellow at Stanford’s Woods Institute for the Environment.

“Some parts of the world, including much of China, use far too much fertilizer,” Vitousek said. “But in sub-Saharan Africa, where 250 million people remain chronically malnourished, nitrogen, phosphorus and other nutrient inputs are inadequate to maintain soil fertility.”

China and Kenya

In the Science report, Vitousek and colleagues compared fertilizer use in three corn-growing regions of the world—north China, western Kenya and the upper Midwestern United States.

In China, where fertilizer manufacturing is government subsidized, the average grain yield per acre grew 98 percent between 1977 and 2005, while nitrogen fertilizer use increased a dramatic 271 percent, according to government statistics. “Nutrient additions to many fields [in China] far exceed those in the United States and northern Europe—and much of the excess fertilizer is lost to the environment, degrading both air and water quality,” the authors wrote.

Co-author F.S. Zhang of China Agriculture University and colleagues recently conducted a study in two intensive agricultural regions of north China in which fertilizer use is excessive. Their results showed that farmers in north China use about 525 pounds of nitrogen fertilizer per

acre (588 kilograms per hectare) annually—releasing about 200 pounds of excess nitrogen per acre (227 kilograms per hectare) into the environment. Zhang and his co-workers also demonstrated that nitrogen fertilizer use could be cut in half without loss of yield or grain quality, in the process reducing nitrogen losses by more than 50 percent.

At the other extreme are the poorer countries of sub-Saharan Africa, such as Kenya and Malawi. In a 2004 study in west Kenya, co-author Pedro Sanchez and colleagues found that farmers used only about 6 pounds of nitrogen fertilizer per acre (7 kilograms per hectare)—little more than 1 percent of the total used by Chinese farmers. And unlike China, cultivated soil in Kenya suffered an annual net loss of 46 pounds of nitrogen per acre (52 kilograms per hectare) removed from the field by harvests.

“Africa is a totally different situation than China,” said Sanchez, director of tropical agriculture at the Earth Institute at Columbia University. “Unlike most regions of the world, crop yields have not increased substantially in sub-Saharan Africa. Nitrogen inputs are inadequate to maintain soil fertility and to feed people. So it’s not a matter of nutrient pollution but nutrient depletion.”

U.S. and Europe

The contrast between Kenya and China is dramatic and will require vastly different solutions, the authors said. However, large-scale change is possible, they said, noting that since the 1980s, increasingly stringent national and European Union regulations and policies have reduced nitrogen surpluses substantially in northern Europe.

In the Midwestern United States, over-fertilization was the norm from the 1970s until the mid-1990s. During that period, tons of excess nitrogen and phosphorus entered the Mississippi River Basin and drained

into the Gulf of Mexico, where the large influx of nutrients has triggered huge algal blooms. The decaying algae use up vast quantities of dissolved oxygen, producing a seasonal low-oxygen dead zone in the Gulf that in some years is bigger than the state of Connecticut.

Since 1995, the imbalance of nutrients—particularly phosphorus—has decreased in the Midwestern United States, in part because better farming techniques have increased yields. Statistics show that from 2003 to 2005, annual corn yields in parts of the Midwestern United States and north China were almost the same, even though Chinese farmers used six times more nitrogen fertilizer than their American counterparts and generated nearly 23 times the amount of excess nitrogen.

“U.S. farmers are managing fertilizer more efficiently now,” said co-author Rosamond Naylor, director of Stanford’s Program on Food Security and the Environment. However, environmental problems have not disappeared. “The dead zone in the Gulf of Mexico persists due to continued fertilizer runoff and animal waste from increased livestock production,” said Naylor, a professor of environmental Earth system science and senior fellow at Stanford’s Woods Institute and Freeman Spogli Institute for International Studies.

Low nitrogen in Africa

In sub-Saharan Africa, the initial challenge is to increase productivity and improve soil fertility, the authors said. To meet that challenge, co-author Sanchez recommends that impoverished farmers be given subsidies to purchase fertilizer and good-quality seeds. “In 2005, Malawi was facing a serious food shortage,” he recalled. “Then the government began subsidizing fertilizer and corn seeds. In just four years production tripled, and Malawi actually became an exporter of corn.”

Food production is paramount, added co-author G. Philip Robertson, a

professor of crop and soil sciences at Michigan State University. “Avoiding the misery of hunger is and should be a global human priority,” Robertson said. “But we should also find ways to do this without sacrificing other key aspects of human welfare, among them a clean environment. It doesn’t have to be an either/or choice.”

For countries where over-fertilization is a problem, the authors cited a number of techniques to reduce environmental damage. “Some of these—such as better-targeted timing and placement of nutrient inputs, modifications to livestock diets and the preservation or restoration of riparian vegetation strips—can be implemented now,” they wrote.

Designing sustainable solutions also will require a lot more scientific data, they added. “Our lack of effective policies can be attributed, in part, to a lack of good on-farm data about what’s happening with nutrient input and loss over time,” said co-author Alan Townsend, an associate professor of ecology and evolutionary biology at the University of Colorado-Boulder. “Both China and the European Union have supported agricultural research that yields policy-relevant information on nutrient balances. But the U.S. is particularly lacking in long-term data for a country with such a well-developed scientific enterprise.”

Even in Europe, with its strong research programs on nutrient balances and stringent policies for reducing fertilizer runoff, nitrogen pollution remains substantial. “The problem of mitigation of excess nitrogen loss to waters is not easily resolved,” said co-author Penny Johnes, director of the Aquatic Environments Research Centre at the University of Reading, U.K. “Society may have to face some difficult decisions about modifying food production practices if real and ecologically significant reductions in nitrogen loss to waters are to be achieved.”

According to Vitousek, it is important in the long run to avoid following the same path to excess in sub-Saharan Africa that occurred in the

United States, Europe and China. “The past can’t be altered, but the future can be and should be,” he said. “Agricultural systems are not fated to move from deficit to excess. More effort will be required to develop intensive systems that maintain their yields, while minimizing their environmental footprints.”

Other co-authors of the Science report are Tim Crews, Prescott College; Mark David, University of Illinois at Urbana-Champaign; Laurie Drinkwater, Cornell University; Elisabeth Holland, National Center for Atmospheric Research; John Katzenberger, Aspen Global Change Institute; Luiz Martinelli, University of São Paulo, Brazil; Pamela Matson, Stanford University; Generose Nziguheba, Columbia University; Dennis Ojima, The H. John Heinz III Center for Science, Economics and the Environment; and Cheryl Palm, Columbia University.

This work is based on discussions at the Aspen Global Change Institute supported by NASA, the William and Flora Hewlett Foundation, and the David and Lucile Packard Foundation; and at a meeting of the International Nitrogen Initiative sponsored by the Scientific Committee on Problems of the Environment.

Provided by Stanford University (news : web)