

Production Practices for Major Crops in U.S. Agriculture, 1990-97

Merritt Padgitt
Doris Newton
Renata Penn
Carmen Sandretto

Introduction

Changes in U.S. farming practices since the end of World War II have brought large increases in agricultural productivity. However, soil erosion, sedimentation in streams and reservoirs, pollution of surface waters, contamination of ground water, and degradation of wildlife habitats have, at least partially, been attributed to the use of agricultural chemicals and changes in crop production practices [NRC, 1989]. The potential exposure to agricultural chemicals poses a health risk to farmers and farmworkers [Litovitz, Schmitz, Bailey, 1990; Ciesielski, Looms, Miss, and Amer, 1994], while the possibility of chemical residues in drinking water or food is a concern of consumers [Alavanja, Blair, McMaster, and Sandler, 1996; van Ravenswaay, 1995; Buzby and Skees, 1994; Collins, 1992; NRC, 1993]. Farmers are the primary decisionmakers on how they combine their production resources and management skills to produce food and fiber, but increasingly they face pressures to use production systems that are friendlier to the environment and pose fewer potential health risks.

This bulletin reports the results of farm commodity surveys conducted between 1990 and 1997 by USDA. The surveys provide information on chemical inputs in agriculture and the use of farming practices that may affect the intensity with which fertilizers and pesticides are used or their potential cost to the environment. How agricultural chemicals and practices ultimately affect human health or the environment is a complex process and requires research beyond the scope of this report. Data in this report, however, can help answer questions about how intensively agricultural chemicals are used and what practices are used that may abate (or exacerbate) undesirable effects. Besides supporting research on such environmental and social issues, the data can also help private industry to assess potential markets for biotechnology or other production inputs that may offer both environmental and health benefits.

Historical Trends in Farming Practices

Farming practices have evolved considerably throughout U.S. history. In the last 200 years, U.S. farming technology has evolved from an individual, labor-intensive process into a capital-intensive and highly skilled but labor-efficient one. Changes in mechanical, chemical, and biological technologies are often cited as responsible for the changes in agricultural production practices. Each period has brought new technologies and practices that have unleashed large gains in agricultural productivity, but sometimes at the cost of increased stresses on natural resources.

In the precolonial and colonial periods, agriculture was labor-intensive and conducted with crude tools and limited use of draft animals [Edwards, 1940]. Labor was scarce and new land was plentiful, so farmers made little effort to protect their soil from erosion or to replenish soil nutrients. The moldboard plow became widely used to till the soil and prepare weed-free seedbeds for good early plant growth. The practice, however, disturbed the soil structure and removed vegetative cover, leaving the land more susceptible to soil erosion and a potential source of water quality problems.

The mechanical revolution (mid-1800's to the beginning of World War II) brought rapid changes in farm power sources, farm implements, and transportation [Hambidge, 1940]. Tractors replaced draft animals, and many other labor-saving machines allowed farmers to farm more land with less labor. Improved transportation and storage allowed farm products to be transported longer distances to growing markets. Mechanized agriculture allowed more intensive use of cropland and often brought more fragile land into production that had greater potential for soil erosion. The stress on the land and the need for natural resource protection became apparent from abandoned cropland, gullies dissecting fields, the high volume of silt in streams and rivers, and the 1930's "dust bowls" [Bennett, 1939]. Voluntarily, either at their own expense or with Federal subsidies, many farmers adopted contour and strip farming practices, installed terraces and

grassed waterways, or used crop rotations and other means to protect their land [Parks, 1952].

Advances in chemical manufacturing following World War II introduced many new products to agriculture to supplement soil nutrients and to control pests [NRC, 1989; Blackman, 1997]. High-analysis chemical fertilizers such as super phosphate, urea, and anhydrous ammonia came to be substituted for manure, bloodmeal, and other organic materials previously used to supply plant nutrients. Commercial fertilizers restored nutrient-deficient soils and gave farmers the option for continued intensive production of crops. Synthetic pesticides greatly expanded pest management options and crop production choices. The ability to chemically control weeds significantly reduced the need for capital- and labor-intensive tillage methods and allowed farmers to further expand the size of their operations. Reducing the risk of damages from insects or disease with pesticides also helped to stabilize yields and prices. Pesticides that stimulated uniform growth patterns, defoliated plants, or caused simultaneous fruit ripening made machine harvesting feasible or more efficient and replaced agricultural laborers.

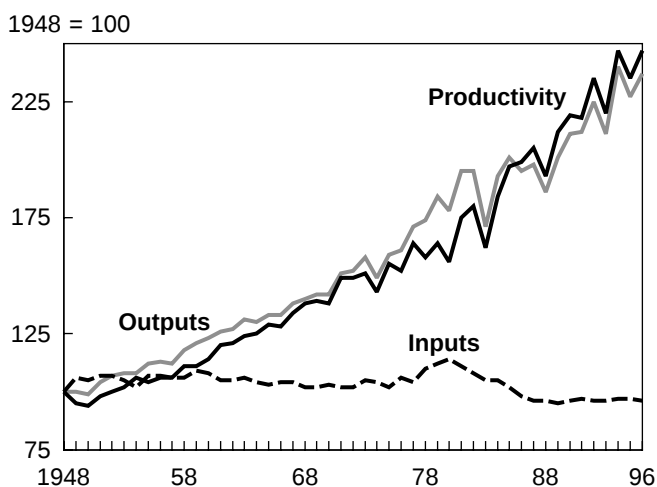
Other major innovations during this period included improvements in plant breeding and genetics. New seeds that were higher yielding, superior in grain quality, resistant to diseases, tolerant of a wide range of weather conditions, or uniform in size and maturity contributed to increased productivity [Gresshoff, 1997]. With these improvements came the need for additional fertilizer to support the higher yields. Genetic engineering, which develops seeds that can produce their own toxins against insect pests or that are resistant to the application of broad-based herbicides, now provides farmers with additional options for pest control that may lead to changes in pesticide use.

Growth in Productivity, Output, and Inputs, 1948-96

The effect of agricultural technologies is reflected in the indicators of growth in agricultural productivity (fig. 1A). Agricultural productivity is measured by comparing total outputs to total inputs in the agricultural sector for a given period. Productivity grows when real output increases faster than the growth in the use of combined inputs. Agricultural productivity rose more than 230 percent between 1948 and 1996, an annual rate of 1.9 percent [Ahearn, Yee, Ball, and Nehring, 1998]. The input indicator, an aggregate measure of all inputs, fell during this period, largely as a result of declines in labor input. The declines in labor use were offset by increases in other inputs such as farm machinery, improved seeds, fertilizers, and pesticides.

Figure 1A

Growth in productivity, outputs, and inputs, 1948-96



Source: Ahearn, Yee, Ball, and Nehring, 1998

Trends in Use of Fertilizer and Pesticide

While the aggregate of all inputs in agriculture has dropped, the use of chemicals has increased (fig. 1B). The quantity of active ingredients in both nutrients and pesticides showed a continuous upward trend until the early 1980's. During this time, fertilizers and pesticides were applied to more acres, and application rates increased. Since about 1982, total agricultural chemical use has varied, mainly with changes in planted acreage, government set-aside requirements, weather, and levels of pest infestation.

Pesticide use, as conventionally reported in pounds of active ingredients, does not account for the many changes in pesticide products over the last several decades. Many newer products are more selective in the pests they control and less persistent in the environment. Newer products are frequently applied at lower application rates with equal or improved efficacy. When adjustments were made for such changes in quality and potency over time, the upward trend in the pesticide indicator continued after 1982 [Ahearn, Yee, Ball, and Nehring, 1998].

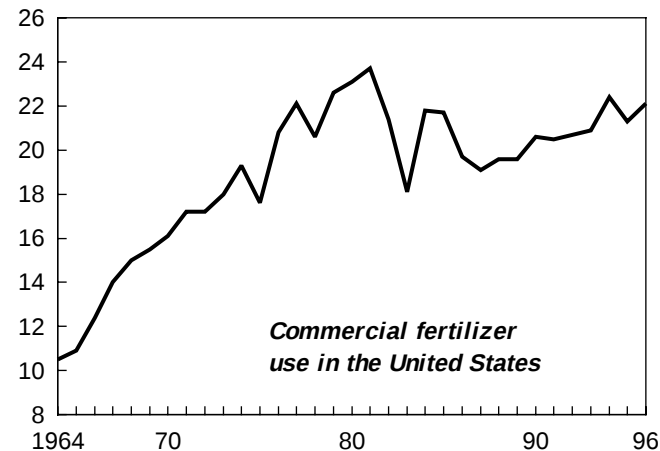
Environmental Effects from Agricultural Production

Agriculture affects the environment through many complex physical/biological relationships, not all of which are fully understood. The physical attributes, application methods, episodic weather events, and timing of chemical inputs along with soil and water management practices can have a major effect on the transport and risk exposure of agricultural chemicals to humans or wildlife species.

Figure 1B

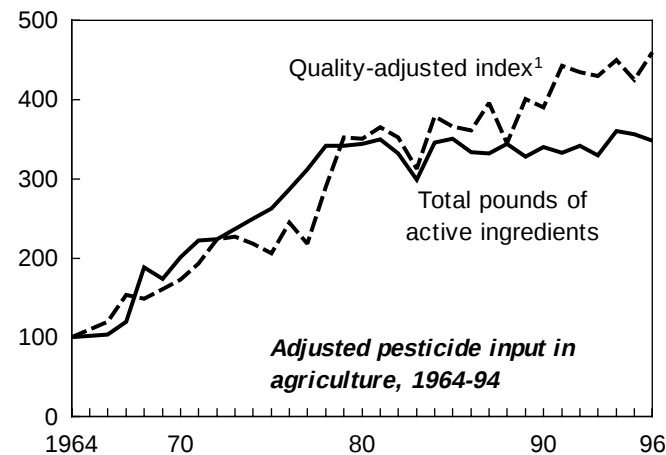
Trends in use of fertilizer and pesticide

Million nutrient tons



Source: USDA, ERS, 1997.

1964=100



¹Adjusted for changes in the mix of pesticide ingredients and their ability to kill selected target pests and in their effects on the environment.

Source: Ahearn, Yee, Ball, and Nehring, 1998

Even though major strides have been made in recent years to reduce surface water pollution from nonagricultural sources, surface water pollution continues to dominate water quality issues. In the National Water Quality Inventory (1996), the U.S. Environmental Protection Agency (EPA) reported that agriculture ranks first as the leading source of water quality problems for lakes and rivers, and ranks fifth for contributing to the degradation of estuaries. The combined effects of agricultural activities, including livestock facilities, were reported to have contributed to the impairment of 25 percent of the river miles, 19 percent of the lake areas, and 10 percent of estuary areas surveyed in the National Water Quality Inventory [EPA, 1999]. The survey represented approximately 19 percent of the rivers, 40 per-

cent of the lakes, and 72 percent of the estuaries in the Nation. The results do not represent unsurveyed portions of these U.S. water resources. Of the impaired rivers, 18 percent were impaired by siltation, 14 percent by nutrients, and 7 percent by pesticides. Siltation and nutrients were also major contributors to the impairment of lakes and estuaries.

Ground water quality has also been affected by agricultural residuals. The contamination of ground water is particularly important because ground water provides drinking water for half of the U.S. population and removing chemical residues is extremely difficult and costly. Because of the slow-moving nature of ground water, the concentration of contaminants can increase over time and persist for many years. Tumors (malignant or nonmalignant), reproductive disorders, and neurological problems are among the potential health concerns when threshold levels of certain pesticides are reached [Blair, 1992].

The National Survey of Drinking Water Wells conducted in 1988-90 provides some indication of agriculture's impact on ground water [EPA, 1995]. Nitrates were the most frequently detected chemicals in ground water used as a source for drinking water. The EPA reported that about 4.5 million people using water from community well water systems or rural domestic wells were exposed to nitrates exceeding maximum contaminant levels set by the EPA. Excess nitrates in drinking water have been linked to methemoglobinemia, a condition that impairs the ability of an infant's blood to carry oxygen, and have been suggested to increase cancer risk [National Research Council, 1995]. The U.S. Geological Survey's ground water monitoring found that wells in agricultural areas more often exceeded the maximum contaminant levels for nitrogen than wells in other areas [Mueller and Helsel, 1996]. The EPA survey estimated that less than 1 percent of the rural domestic wells or wells used for community water systems had any pesticide concentrations exceeding the lifetime health advisory levels. The most frequently detected pesticide in ground water supplied to public water systems was atrazine [EPA, 1995]. The uses of agricultural chemicals have also harmed wildlife through direct contact, destruction of food supplies, or alteration of habitats. Wetlands and aquatic ecosystems in agricultural watersheds are most vulnerable. Agriculture has been identified as a source of pollutants that caused fish kills [EPA, 1995]. In 1,454 fish kills reported in 32 States and other U.S. jurisdictions in 1992-93, pollution was the cause about one-third of the time. Toxic pollutants, which were most often agricultural pesticides, were the cause for about 5 percent of the kills.

Organization of Report

The estimates of cropping practices and chemical use presented in the following chapters are based on several independent commodity surveys. Estimates from these surveys have been consolidated to represent nearly 60 percent of the U.S. cropland used for crops. The commodities include major field crops (corn, soybeans, wheat, cotton, and fall potatoes) and 24 fruit and 21 vegetable crops. While the commodities included in the surveys represent a large share of cropland and chemical inputs in agriculture, other agricultural commodities also use significant quantities of commercial fertilizers and pesticides and may have environmental impacts. Crops not represented include both those that have relatively intensive use of inputs, such as rice, tobacco,

and horticultural crops, as well as those that have lower input use, such as hay and fallow.

Chapters II and III present information on the use of fertilizer and nutrient management practices and pesticides and pest management practices. The next chapter discusses the use of general crop management practices such as crop rotations and cover crops and associated chemical usage. The last chapter presents information on tillage systems and other practices related to soil management and the chemical use associated with these practices. In addition to the appendix tables in this report, an electronic data product is available that provides State-level estimates and additional detail about the cropping practices reported in this bulletin.