Summary

The U.S. seed industry changed dramatically over the past century, as more farmers purchased their seed (instead of using seed saved from the previous harvest) and small seed businesses gave way to larger enterprises that integrated plant breeding, production, conditioning, and marketing functions. The industry was further shaped by widespread mergers and acquisitions in the latter part of the 20th century, rapid growth in private research and development (R&D), shifting roles of public and private R&D, and a "coming of age" of agricultural biotechnology.

To assess these developments, this report examines the composition of U.S. and international seed markets, regulations affecting agricultural seeds, the structure and evolution of the seed industry, and trends in private and public R&D in plant breeding. Particular emphasis is placed on seeds for the major field crops: corn, cotton, soybeans, and wheat.

Improved Seed Is a Major Contributor to Crop Yield Gains

Over the past 70 years, yields of all major field crops in the United States registered a remarkable increase. For example, average corn yields rose from 20 bushels per acre in 1930 to 140 bushels per acre by the mid-1990s. Over the same period, cotton yields rose nearly fourfold, soybean yields increased more than threefold, and wheat yields climbed more than 2.5-fold. More than half of the yield gains are attributed to genetic improvements achieved by plant breeders.

Purchased Seed Use, Purchase Value, and Trade Have Grown in Recent Decades

The United States is the largest seed market worldwide, followed by China and Japan. Seed expenditures by U.S. farmers rose from about $500 million per year in 1960 to nearly $7 billion in 1997. In real terms, seed expenditures climbed about 2.5-fold in the same period, despite minimal real increases in the index of seed prices paid by farmers. A large portion of the increase in real seed expenditures may be explained by increases in the share of seed purchased by U.S. farmers from commercial sources, which, in turn, can be explained by increases in seed productivity attributable to scientific improvements in plant breeding. The United States is a net exporter of seed. In 1996, the U.S. seed trade surplus was $384 million: $698 million in seed exports, mainly to Mexico, Canada, Italy, Japan, and Argentina; and $314 million in seed imports, mainly from Canada, Chile, the Netherlands, and China.

Intellectual Property Rights Effect Significant Changes

Hybrid corn varieties developed in the first half of the 20th century and, widely accepted by farmers, provided the private sector a natural method of protecting plant breeding investments—saved hybrid corn seed produces substantially lower yields, encouraging farmers to repurchase seed every year. This development, combined with a strengthening of legal protection of intellectual property rights in the second half of the 20th century, brought large-scale change to the seed industry, particularly increases in R&D and industry concentration.

Seed Industry Structure Is Characterized by Growth and Consolidation

From the commercial production of hybrid corn seed in the 1930s to the recent mergers and acquisitions, the history of the U.S. seed industry is marked by extensive structural change and transition. Until the 1930s, most commercial seed suppliers were small, family-owned businesses lacking the financial resources necessary to pursue their own research and development. These small businesses depended almost exclusively on plant breeding research in the public sector. Seed businesses served primarily to multiply and sell seeds of varieties developed in the public domain.

Market concentration in the U.S. seed industry increased in the latter part of the 20th century, with the four largest corn seed firms accounting for nearly 70 percent of U.S. corn seed sales in 1997 and the four largest cotton seed firms providing more than 90 percent of the cotton seed varieties planted. In contrast, the public sector still accounts for a large share of the wheat seed varieties used by U.S. farmers. Although the increase in seed industry concentration has raised concerns about its potential impact on market power, preliminary empirical results for U.S. cotton and corn seed industries over the past 30 years suggest that increased concentration resulted in a cost-reducing effect that prevailed over the effect of enhanced market power.

Private and Public Sector Roles in Crop Seed R&D Have Shifted

Private R&D expenditures on plant breeding increased 1,300 percent between 1960 and 1996 (adjusted for inflation), while real public R&D expenditures changed little. With the development of commercially viable corn hybrids in the 1930s, R&D expenditures on corn varieties were the first to shift from public to private. Private seed companies' share of total expenditures on plant breeding R&D on corn increased from close to half in 1970 to more than 70 percent in 1989. The shift from public to private R&D expenditures on soybean plant breeding is more recent, as the share of private sector R&D for soybeans rose from 6 percent to almost 25 percent between 1970 and 1984. Private sector R&D for improved wheat varieties has been limited. As a result, farmers have relied on public sector wheat varieties for new sources of seed. Public sector research also emphasizes many minor field crops, such as oats and barley. Although a large amount of plant breeding R&D shifted from the public sector to the private sector, ample research opportunities still exist for both sectors.

Introductions and Trials of New Varieties Are Increasing Over Time

Improved plant varieties are a product of research and development. Seeds embody the scientific knowledge needed to produce a new plant variety with desirable attributes, such as higher yield potential, greater disease resistance, or improved quality. The number of plant variety protection (PVP) certificates issued by USDA provides a useful indicator of plant breeding research efforts. The number of PVP certificates issued by USDA has grown rapidly since the 1970 Plant Variety Protection Act. This growth suggests the positive effects of the Act on generating private sector incentives for plant breeding R&D. Growth in PVP certificates has been highest for soybeans and corn, which together account for more than half of

all certificates issued for field crops. By the end of 2002, 2,612 certificates had been issued for varieties of U.S. origin for the four major field crops, including 1,078 for soybeans, 648 for corn, 568 for wheat, and 290 for cotton. Most PVP certificates are held by the private sector.

As indicated by the number of field releases issued by USDA's Animal and Plant Health Inspection Service (APHIS) to allow breeders to pursue field testing, plant breeding research through biotechnology is increasing. Between 1987 and June 2001, APHIS received over 7,600 applications for field releases of biotech varieties and approved 6,700. The number of applications received annually by APHIS increased from 9 in 1987 to 1,206 in 1998. The majority of applications for field releases received from private and public institutions are for testing improved varieties of major crops. By mid-2001, more than 3,300 applications had been received for corn varieties. Other field release applications included 761 for potatoes, 601 for soybeans, 532 for tomatoes, 481 for cotton, and 209 for wheat.

After undergoing years of field tests, extensive review, and determination by APHIS that unconfined release of a genetically modified organism does not pose a significant risk to agriculture or the environment, the organism in question is no longer considered a regulated article and can be moved and planted without APHIS authorization. As of mid-2001, APHIS had received 79 petitions for deregulation and had granted 53. Thirty-six percent of these deregulated varieties have herbicide-tolerance traits, 20 percent have insect-resistance traits, and 19 percent have traits to improve product quality.