Economic Issues in Agricultural Biotechnology

Introduction

U.S. agriculture has always been one of the most highly productive sectors in the economy. Productivity growth rates since 1947 have averaged nearly 2 percent per year, resulting in continual supplies of food, feed, and fiber produced at affordable prices. Continuous advances in productivity are the result of the development of improved production inputs (feed, fertilizers, pesticides, etc.) and technologies combined with effective onfarm management of these new technologies. These advances come from research and development (R&D) investments within both the public and private agricultural research sectors.

Historically, private research focused on mechanical and food processing technologies, while the public sector emphasized the development of new plant varieties and improvement of animal breeds using traditional breeding techniques. While these methods produced many important advances, such as hybrid and other high-yielding crops, the research required to introduce desirable traits was slow and labor intensive. Since the discovery of the double-helix structure of DNA and the subsequent innovations in gene manipulation, scientists have struggled to find ways to exploit this knowledge. These efforts have significantly advanced biological science and the development of biotechnologies, which will be major contributing factors to future agricultural productivity growth.

Modern plant biotechnology methods, such as cell culture and genetic engineering, have led to the development of novel plant varieties that would not have been possible using traditional breeding methods. Advances in genetic mapping and gene transfer and in the manipulation of gene regulation are allowing scientists to redraw the genetic blueprints of plants and animals. The genetic modification of organisms by recombinant DNA techniques can range from either enhancing or suppressing the performance of existing genes to transferring genetic information from one organism into a host organism. Genetic engineering simplifies the identification of the genes responsible for particular desirable traits and allows scientists to precisely transfer single traits between species. Thus, seed developers can decrease the number of unintended characteristics that are possible with traditional breeding methods and speed up the development of new strains by reducing the need for repeated backcrossing when breeding in new traits.

The ability to insert or affect desirable traits in plants has produced a *first generation* of biotechnology products that enhance the production practices of farmers. For example, the insertion of the insecticidal Bt gene from the bacterium *Bacillus thuringiensis* into cotton reduces the need for some chemical insecticides and has the potential of reducing production costs for farmers. A *second generation* of biotechnology products expands the opportunities for farmers even more through various quality enhancements, such as corn or soybeans with higher protein or oil content—modifications that facilitate processing (high-solids potatoes)—or crops designed to produce high-value pharmaceuticals or industrial chemicals.

As with most technological advances, the benefits come at some costs. Changes in technological possibilities often result in some displacement or changes in institutional arrangements. The advent of the internal combustion engine and ultimately the automobile, while clearly a benefit, displaced horse-shoeing and buggy whip manufacturing and produced environmental consequences unforeseen and undesirable. At the same time, new technologies create new jobs and opportunities. Some have called the last half century "The Age of Physics" due to the important scientific advances associated with subatomic particles and to learning more about the origins of the universe. The explosion of discoveries and advances in the science of biology suggests that the next century may well be "The Age of Biology." The age of biology will present significant opportunities for agriculture but will also involve numerous issues and concerns that need to be

addressed along the way. This document presents a discussion from the perspective of economics of many of those issues and their potential impact on the structure of the U.S. agricultural economy.

The issues associated with agricultural biotechnology are varied and rapidly evolving. New issues develop even as we write this document, making it difficult to keep current.

We have divided the issues into three sections. First, we provide some background and identify important advances in biological science, where these advances occurred between the public and private research sectors, and the changes in patent law that allowed private firms to capitalize on these discoveries.

Second, we consider important trends, especially in current adoption rates of biotechnologies by farmers and in farm-level effects of adoption. New marketing and contractual arrangements between farmers and grain and food processors are beginning to develop and will likely become critical issues as more genetically engineered (GE) crops enter the marketplace. These issues are explored, along with the implications for grades and standards for GE products.

Third, we address issues associated with production and distribution of GE products, as the ability for the agbiotech market to expand depends on the demand for these new products. We look at the demand side—that is, we consider consumer preferences, particularly the difference in perspective between U.S. and European consumers and the implications for trade. We examine public policies that affect the distribution of biotechnology research between the public and private sectors. We also look at biotechnology in a global context, including the potential role biotechnology can play in feeding a growing world population and how agricultural research can help address these issues.