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PURDUE AGRICULTURAL ECONOMICS REPORT

MARCH 2000

Agricultural Biotechnology: What's all the fuss about?

Marshall A. Martin, Professor and Associate Head*

Frankenfood or silver bullet? The current debate over agricultural biotechnology is raging in the news media, in agribusiness boardrooms, among consumer and environmental activist groups, among government officials and international trade negotiators, within the scientific community, and in rural communities across this nation.

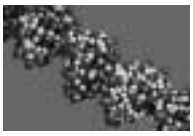
Biotechnology is truly ubiquitous. Everyone is impacted directly or indirectly by the products of biotechnology now flowing out of the laboratories, farms, and food processing plants throughout much of the world. How did this new science evolve? What has happened in recent months? What does it mean for society? And, where are we headed?

This article provides background on biotechnology, explores the expected benefits and possible risks associated with the products of biotechnology, and offers insights on potential current and future societal impacts.

The Scientific Foundation

Some say that biotechnology is nothing new. Mankind has domesticated plants and animals for thousands of years. Enzymes have been used since Biblical times to produce cheese, bread, beer, and wine. Gregor Mendel, in the mid-19th Century, established the basic laws of genetics that led to our understanding of inheritance traits and the role of genes in transferring these traits among offspring of plants and animals. The ensuing applications of Mendelian genetics have resulted in hybrid corn, leaner hogs, more milk production per dairy cow, and the development of disease resistant crops. Thus, science has helped increase agricultural productivity.

But something is new today. Modern biology has its roots in the pioneering research by Nobel Laureates Drs. Watson and Crick. In the early 1950s, they unraveled the mystery of how the "code of life" is transferred from one generation to the next through the spiral-helix. Their research helped us understand how deoxyribonucleic acid (DNA) functions as an information storage system that can be easily and accurately replicated. DNA is composed of four building blocks denoted by their nitrogenous base components: A (adenine), C (cytosine), G (guanine), and T (thymine). With the 26 letters of the alphabet, we use various sequences of letters to form words and sentences in English to store and communicate information. In an analogous fashion, these four nucleotides can be placed in various chemical combinations to store and communicate biological information. Most DNA molecules are extremely long strands of millions of nucleotides. Like a zipper on a jacket, these building blocks are placed in a double strand, which can be "unzipped" or rearranged to transfer genetic information.



Proteins do virtually all the work in the cells that contain the DNA. The cells use the information in the DNA to determine what the proteins should do. By inserting a new gene in the DNA, which occurs with genetic engineering, a new message can be sent to produce new proteins or modify existing proteins in the cell structure.

The techniques of molecular biology or biotechnology have made it possible for scientists to move genes into the DNA of one plant or organism from another plant or organism.

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In This Issue

The resulting plant or organism can be referred to as "transgenic". Such a transfer of a gene would not be possible through classical genetics or plant breeding. It is the development of these techniques of gene transfer or genetic engineering that has given rise to new processes and products that are increasingly pervasive in medicine, food processing, and agriculture. (See Figure 1 for an example of transferring a gene from a soil bacterium that can express insect resistance in corn.)

Medical Applications of Biotechnology

One of the first major applications of biotechnology was the development of a genetically engineered version of insulin. For decades, companies like Eli Lilly in Indianapolis had purified insulin from the pancreas of hogs and cattle. Diabetics could inject this animal-based insulin on a regular basis to regulate their blood sugar. With a growing and aging population, and improved medical diagnosis, the incidence and cost of treating diabetes with animal-based insulin was increasing. Also, some people's bodies reject these animal-based insulin products.

By taking the gene that codes for insulin from a person's pancreas, and using the techniques of genetic engineering in a laboratory using appropriate E.Coli bacteria, Eli Lilly scientists were able to produce a pure copy of human insulin in large, relatively inexpensive quantities. After many years of careful testing, the Food and Drug Administration approved the commercial sale of Humalin® or Humalog® for the treatment of diabetes. This product of biotechnology is widely used by diabetics throughout the world.

Vaccines against many common diseases, human growth hormones to treat dwarfism in children, laboratory assays such as the home-pregnancy test, and many other applications of biotechnology are common in the medical community today. In addition, a whole new field of "farmaceuticals" is emerging as pharmaceutical products such as blood clotting agents are produced in goats' milk.

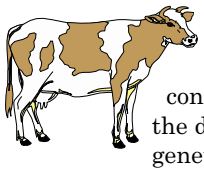
Food Processing

The processing of many foods requires the use of enzymes to convert starches or proteins into desired end products. Examples include extracting fructose from corn, converting the starches in barley or grapes into sugar that can then be fermented to make beer or wine, or converting the proteins in milk into cheese curds.

Rennin has been used for centuries to produce cheese from milk. Rennin is found in the stomach of a veal calf. Using the process of genetic engineering, a version of rennin called chymosin has been produced in a laboratory. Today, nearly 80% of the cheese consumed in the United States is processed using chymosin.

Livestock Production

In the 1980s, four different companies, Cyanamid, Upjohn, Elanco, and Monsanto conducted research on the development of genetically engineered Bovine Somatotropin (Bst). Bst, a protein hormone produced in the pituitary gland of dairy cows, is partially responsible for stimulating milk production in the mammary glands. Animal scientists have been aware of this process for many decades. It is now possible, using the process of genetic engineering, to extract from the pituitary gland of a dairy cow the gene that codes for Bst and then cheaply produce large quantities of Bst in a laboratory using E.Coli bacteria.



In the late 1980s, Monsanto successfully did this and then patented a method to inject Bst into a dairy cow on a monthly basis during the latter months of lactation. The commercialization of this product, under the brand name Posilac®, was launched in the United States in February 1994. Currently, about 15% of U.S. dairy farmers, who manage about one-third the dairy herd, use this product. It can increase daily milk production by about 10 pounds per cow.

Bst was not launched without controversy, however. Critics claim that it was not adequately tested and might cause cancer in humans who consumed milk and dairy products from cows treated with Bst. Others were concerned that higher producing cows would have a higher incidence of mastitis requiring greater use of antibiotics which might remain in the milk and adversely affect consumers. Still others were concerned about the impacts on the cows' health including possible reproductive problems. Despite these concerns, U.S. dairy farmers are using Bst, and none of the critics' animal or human health concerns have emerged to date as serious

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problems. In fact, milk and dairy product consumption in the United States continues to increase.

However, in other countries, expressed health and economic concerns have precluded the approval of Bst use by government agencies. For example, Bst is not approved for use in the European Union (EU). Many EU consumer groups are opposed to biotechnology. Also, the EU's Common Agricultural Policy for several decades has imposed a marketing quota system on its dairy farmers that limits milk sales to avoid surpluses of butter, cheese, and other dairy products.

Research continues on other animal applications of biotechnology including Porcine Somatotropin (Pst) to enhance lean muscle growth and reduce fat deposition in hogs. The development of vaccines to control animal diseases also continues.

There are potential animal applications to human medicine. For example, research is underway in what is called xenotransplants. Scientists are exploring the possibility of transplanting animal organs, such as a pig heart, into humans. While this may become a cost-effective way to save human life, it also raises critical ethical questions.

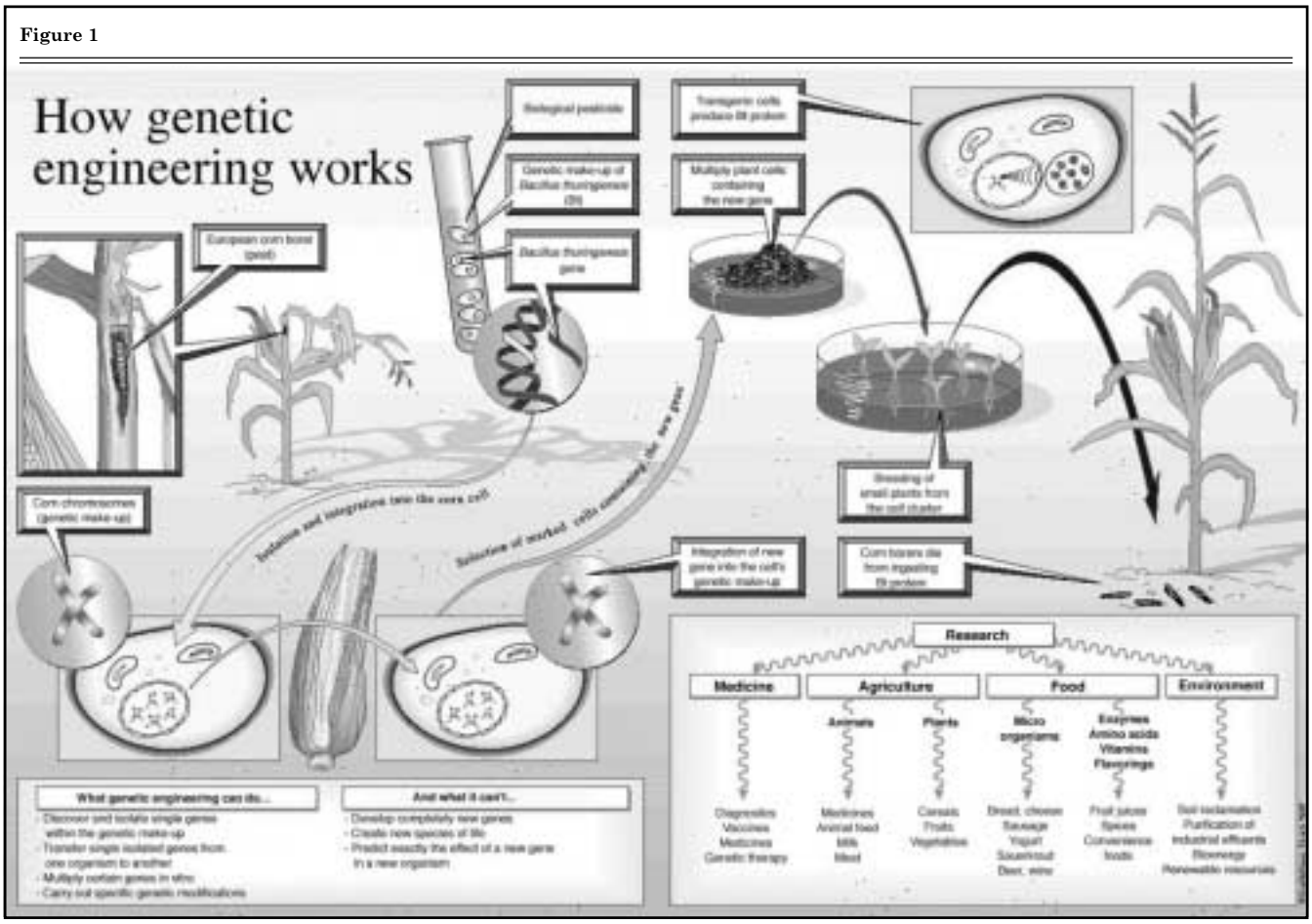
Crop Biotechnology

Weed and insect control has been a challenge for farmers for centuries. Following World War II, pesticides were developed and rapidly adopted by farmers. While most were safe and effective if used properly, some were not, and in isolated cases were removed from the market.

Genetic engineering offers a way to alter crops to resist insect pests or become tolerant to less toxic and environmentally safer herbicides. In 1996, Monsanto, and affiliated seed companies, launched the commercial sale of Round-Up Ready® soybeans. By 1999, 57% of the U.S. soybean acreage was planted to soybean varieties with this herbicide-tolerant trait. Compared to the soil incorporation of some conventional herbicides, this seed technology encourages no-till farming practices, which can help reduce soil erosion and water pollution. The gene that encodes tolerance to the herbicide glyphosate (Round Up®), using the techniques of genetic engineering, was transferred from Agrobacterium sp. strain CP4, a soil bacterium. The gene is a single dominant gene and is stable over several generations.

Bacillus thuringiensis (Bt) is a soil bacterium that has been used for several decades by gardeners and organic farmers to control insects. Using the tools of genetic engineering, scientists have inserted the gene that codes for this protein into several crops including corn, cotton, and potatoes. The crystalline protein has a complex molecular structure. This allows scientists to select the specific

Figure 1



molecular structure that targets a specific insect such as European corn borer in corn, pink budworm and boll weevil in cotton, and Colorado potato beetle in potatoes. Once the target insect ingests a few bites of the plant tissue that contains the Bt protein, the insect's digestive system converts the protein into a toxin that destroys the cell membrane of its stomach and kills the insect. However, when an animal or a human consumes the Bt protein in the plant, the acid environment of the stomach promotes digestion of the protein, without any toxic effects.

In 1999, about one-half the cotton and one-third of the corn acreage in the United States was planted to transgenic varieties. This has resulted in a reduction in insecticide use, primarily for cotton. However, since the high-dose strategy of insect management, if widely adopted, could place extreme pressure on the target insect population, insect resistance management (IRM) programs are essential to minimize the development of insect resistance to Bt. In January 2000, the U.S. Environmental Protection Agency approved a refuge management strategy for corn that requires Midwestern farmers to plant a 20% refuge to non-Bt corn varieties within one-quarter mile of the Bt corn. Entomologists have determined that resistance to Bt is a recessive trait. If some European corn borer survive in the 20% refuge portion of the field and mate with those adults in the portion of the field planted to Bt corn, it is expected that a viable number of European corn borer will survive without the recessive trait, and insect resistance to Bt will be at least delayed, if not avoided.

Besides the input traits such as insect-resistance and herbicide-tolerance, a number of output traits are being introduced into crops. Through genetic engineering, scientists have added vitamin A into rice. Rice is the primary food grain eaten as a staple in the diets of millions of people, especially in the developing world. World health experts hope that these vitamin A enhanced rice varieties will reduce by about 500,000 the number of people who go blind each year and by 2 million the number of children who die each year due to vitamin A deficiency.

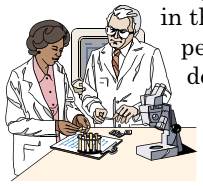
Other examples of output traits include phytase in corn that increases the availability of phosphorous in hog rations and reduces the amount of phosphorous added to the feed premix. With greater utilization of phosphorous in the hog's digestive system, there is less phosphorous in the hog manure and a reduction in the amount of phosphorous applied to fields. This should help reduce hog production costs and offer an environmental benefit.

"Farmaceuticals" such as genetically engineered tobacco to produce cancer-treating drugs are under development. Also crops such as bananas and potatoes have been engineered to deliver selected vaccines against childhood diseases.

The development of output traits through biotechnology will require producers to follow strict identity preserved practices including cultural practices, careful cleaning of harvesting equipment, and separate storage facilities. Those who are able to do this effectively should expect to receive a premium for adding value to the product.

Who regulates biotechnology?

Environmental quality and food safety are critical issues in the minds of many people. People wonder if these genetically engineered crops will have an adverse impact on biodiversity, water quality, or soils. Others wonder if these genetically engineered foods are safe to eat and if they might have some undesirable long-term impact on human health.



To address these concerns, the United States has three major regulatory agencies—The United States Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). Under Federal law each agency has specific regulatory authority.

The Animal and Plant Health Inspection Service in the USDA has oversight responsibility for the movement of seed across state lines. It also must authorize field-testing of any genetically engineered crops. Researchers, whether in the private sector, government laboratory, or university setting, must obtain approval before initiating any field-testing. Scientific peer review of the proposed research protocol is essential. This protocol must clarify the purpose of the research, how and where it will be conducted, what data will be gathered, how the test site will be monitored and secured, and how any crop residue will be disposed. Such reviews can take many months, and sometimes years, depending on the environmental and scientific issues associated with a specific field experiment.

The EPA has the authority to regulate pesticides and the environmental impacts of biotechnology discoveries. For example, by genetically engineering the Bt trait in corn, cotton, and potatoes, these crops technically become a pesticide and thus under the purview of the EPA. Hence, the EPA carefully examined how these Bt crops might impact the environment prior to their approval. One concern was the potential development of insect resistance if these insect-resistant crops were widely adopted by farmers. Because of this concern, in January 2000 the EPA mandated that any farmer growing Bt corn in the Midwest must plant a 20% refuge to a non-Bt corn variety to minimize the possibility that European corn borers develop resistance to the Bt trait. Insect resistance to Bt is a concern to farmers and agribusiness firms since this new bio-engineered crop might quickly be lost as a means of insect control. Also organic farmers and gardeners fear the loss of the effectiveness of traditional Bt insecticides if Bt crops are widely adopted without an effective refugia strategy.

The FDA has responsibility under the Food, Drug, and Cosmetic Act to regulate food and feed, as well as

human and animal health products. For example, the FDA made two rulings on the use of Bst—one to approve its safety for human consumption and the other on safety for the treated dairy cows. This process took more than a decade, with approval for human safety in 1986, and approval for commercialization to U.S. dairy farmers in 1994. The FDA has reviewed and approved other products of biotechnology such as Bt in cotton, potatoes and corn; Round Up Ready® soybeans; chymosin for cheese production, and several medical applications including treatments for diabetes, arthritis, hepatitis, cystic fibrosis, and several types of cancer.

A European Perspective

Much of the recent anti-biotechnology resistance or concern has come from the European Union. This has impacted multilateral trade and biosafety negotiations, international trade, research investments, intellectual property rights, and marketing decisions by major corporations, and intergovernmental agency relations.

There are several factors that have contributed to this trans-Atlantic controversy. There has been a strong "green" movement in Europe for several decades. Some environmental groups historically have focused on point and nonpoint pollution issues ranging from oil spills in the North Atlantic to confinement livestock feeding and field applications of animal wastes in Western Europe. Recently, organizations such as Greenpeace and Friends of the Earth have played a very active role in preventing the EU from importing Genetically Modified Organisms (GMOs) such as Bt corn and Round Up Ready® soybeans. They have also influenced European government officials to ban the planting of GMO crops by European farmers.

Lack of a credible EU-wide regulatory system appears to limit public trust in these new technologies and food products. The European Union has made considerable progess in recent decades to form a multi-country system of government with a Parliament, regulatory agencies in Brussels, a common currency (Euro), the elimination of national passports to cross EU borders, and the liberalization of intra-European trade. However, much of the food related regulatory responsibility in Europe remains at the national level. While efforts are underway to create a European-wide, coherent regulatory system related to biotechnology and the food and agricultural system, no such coherent regulatory system exists yet.

Several recent food scares have further eroded European confidence in their regulatory system. These scares include the mishandling in Great Britain of the "mad cow" disease, dioxin contamination of livestock feed, and the reported contamination of Coca-Cola® products in Belgium.

This lack of public trust in food regulation and oversight agencies has caused some Europeans to wonder if the products of biotechnology have been adequately tested and reviewed by European authorities. Some Europeans appear to be reluctant to rely too heavily on biotechnology products produced and regulated by U.S. companies and agencies.

When consumers purchase a product, they generally are seeking an actual, or at least perceived, benefit. Some European consumers are not convinced that there is any benefit from consuming bio-engineered products. With the current input-trait oriented biotechnology crops such as Bt corn or Round Up Ready® soybeans, there is no claim that foods based on these crops provide any nutritional or health benefit. In fact, the FDA uses the "substantially equivalent" criterion to judge biotechnology food products as safe when there is no difference in their chemical or nutritional makeup from conventional foods. Moreover, under the EU's Common Agricultural Policy, imports of U.S. corn are subject to a variable import tariff, which results in no price advantage to European consumers even if U.S. production costs and prices decline as U.S. farmers adopt Bt corn. Consequently, it is unlikely that these bio-engineered crops will cost European consumers less. And, given the slightest doubt in European consumers' minds about the food or environmental safety of these products, it is understandable why many Europeans are reluctant to purchase GMO-foods, and why they want some type of labeling system that allows them to select non-GMO foods if they wish.

European attitudes do vary by country and application of biotechnology, however. There tends to be the least support for biotechnology in the Germanic countries (Germany and Austria) and Scandinavian countries (Denmark and Sweden), but less opposition in the Mediterranean countries (Spain, Portugal, and Greece). About three-fourths of the Europeans who responded to a recent Eurobarometer survey supported using biotechnology to detect and treat human diseases. However, there was much less support (one-half or less) for food uses or xenotransplants of organs from animals to humans. Many felt the risks were too high, and had moral objections to the food and organ transplant applications of biotechnology.

American Attitudes

Americans appear to be much more supportive of biotechnology than Europeans. In an October 1999 survey, two-thirds of the consumers favored foods produced using biotechnology and expressed confidence in the current FDA food labeling policies. In fact, about 80% of the respondents indicated that they would prefer a toll-free number or a website rather than a food label about the biotechnology ingredients of a food that they might purchase. However, there is pressure from some consumers for food companies to provide more information about bio-engineered foods.

This recent U.S. consumer survey also reported that three-fourths of

the respondents knew something about biotechnology, and two-thirds expected to benefit from biotechnology in the next five years. More than two-thirds indicated they would purchase food products enhanced through biotechnology that protected crops from insect damage and required fewer insecticides. However, only 40% of the respondents knew that many food products in grocery stores today are genetically engineered.

Asian Experience

Asian countries, especially Japan, are major markets for U.S. agricultural exports. Asian countries currently purchase nearly two-thirds of U.S. corn exports and nearly one-half of U.S. soybean exports. With economic recovery in Southeast Asia from the 1997-99 financial crisis, the potential admission of China into the World Trade Organization (WTO), and expected population and per capita income growth in this region of the world, Asian imports of U.S. agricultural products are essential to the economic health of U.S. agriculture. Adverse attitudes in Asian countries towards biotechnology could have a significant negative impact on U.S. agricultural exports to Asia, and thus U.S. farm income.

Public acceptance survey data on this region are more limited than for the United States or Europe. However, the available data suggest that while most Japanese are not significantly concerned about agricultural biotechnology, many Japanese food importing and processing firms are seeking to purchase non-GMO commodities to satisfy the demands of their consumers.

World Negotiations

The WTO meeting in Seattle in December 1999, and the Biosafety Protocol meeting in Montreal in January 2000 both focused on several biotechnology issues. The current WTO Agreement under the Sanitary and Phytosanitary (SPS) guidelines requires a scientific basis for banning the importation of a commodity for health or food safety reasons. To date, Round Up Ready® soybeans and most of the Bt corn varieties being grown in the United States have been approved by the appropriate government regulatory agencies in the United States, the European Union, Canada, Japan, and elsewhere. Hence, since these are all WTO member countries, any import restrictions on GMO products would need to be science-based, i.e., raise human, animal, and/or environmental safety concerns.

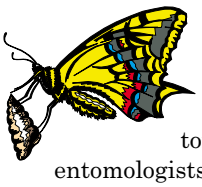
The "Precautionary Principle" agreed to in Montreal allows a country to block imports of GMO commodities on a "precautionary" basis in the absence of sufficient scientific evidence about their safety. Some are concerned that the "Precautionary Principle" will encourage European governments to "protect" their inefficient farmers on the pretext of protecting consumer health. Current WTO sanitary and phytosanitary guidelines require a clear scientific basis to restrict trade of a product that might be hazardous to human or animal health. The agreement reached in Montreal appears to be a "messy compromise." The underlying issue is how to reconcile different attitudes among countries about the risks of technological change without disrupting trade. Should biotechnology move forward unless it is shown to be dangerous, or should it be banned until it is proven safe?

The Biotechnology Critics

The critics of biotechnology raise several issues. Some lack trust in regulatory agencies and feel the regulatory agencies lack the personnel and funding to adequately review the stream of new biotechnology products flowing from the private and public research laboratories. Some anti-biotechnology groups worry about potential adverse long-run impacts of genetically engineering. Often they will mention past experiences such as DDT, mad cow disease, thalidomide, or Chernobyl, where scientists said something was safe and then new information or experience was to the contrary. Hence, part of the debate is about how much testing and study is sufficient to assure the public of the long-term safety of the application of biotechnology to our agricultural and food system.

Those who are concerned about food safety worry that a transgenic gene might behave in some unexpected way and cause an allergic reaction or result in a serious disease. Still others are concerned about adverse environmental consequences such as pollen drift from an herbicide-tolerant crop that might result in a "superweed" that will be difficult to control in the future. Still others worry about insects developing resistance to a pest-resistant crop, and subsequently losing the use of a "bio-pesticide" such as Bt. This is especially a concern among organic farmers and gardeners.

Potential adverse impacts of Bt crops on beneficial insects concern many people. For example, a preliminary laboratory study by entomologists at Cornell University suggested that corn pollen on milkweeds would kill Monarch butterfly larvae. Subsequent field research by several different scientists indicates that the damage to the Monarch butterfly is minimal since the time of the hatch of the larva and corn pollination often differ, corn pollen does not normally drift very far outside the field, and most Monarch butterflies tend to lay eggs in weedy areas outside the corn field.



The Monarch butterfly case illustrates the importance of careful research and monitoring of crops that are bio-engineered to resist insects. It is critical to verify the impact of insect resistant crops on non-target insects, and inform the public of their impact. If there are undesired consequences, then adjustments must be made in the management of the technology, if approved, such as the refuge requirement for those producers who grow Bt corn. And, if there are potential severe

environmental consequences, then the EPA or other appropriate regulatory agencies should not approve the technology.

Other groups raise ethical questions, especially about xenotransplants or cloning of animals. Still others question the control that a few major multinational companies might have over the world's seed and germplasm. And with increased patenting of biotechnology products, this could reduce farmers' independence to purchase inputs and sell their products. Hence, part of the debate is about how the structure of agriculture may change and become more concentrated on a global scale. Some fear further erosion of the family-based farm structure. Biotechnology, along with other economic forces, is encouraging the development of a large, supply-chain oriented global food system.

The U.S. Food Processing Sector Response

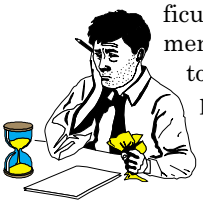
Given the uncertainty about consumer response in North America, and especially in Europe, several major food processors have indicated that they will not use GMO-crops in their foods. Examples include A.E. Staley, National Starch, Gerber, Heinz, and the Frito-Lay corn chip division of Pepsico.

Others that primarily process soybeans or corn for livestock feed use in the United States continue to accept both GMO and non-GMO corn and soybeans. Some grain elevators also are willing to accept corn and soybeans without segregation.

Other firms such as Consolidated Barge and Grain that ship to foreign markets, especially from their Ohio and Illinois River terminals, have asked farmers to segregate their crops. This requires farmers to separate the crop at planting, harvest, and during storage and trucking. Some export-oriented companies have offered premiums of 10 to 20 cents per bushel for non-GMO soybeans and about 10 cents per bushel for non-GMO corn. Expectations for the fall 2000 crop is that it will be a mixed market situation with some firms seeking identity-preserved corn and soybeans with a modest premium, while others will co-mingle the crop and not offer any premiums. The key is whether the crop is for food processing, export, or livestock feed use. Currently, about one-fifth the U.S. corn crop is exported, about one-fifth is processed for food and industrial uses, and the remainder is primarily for livestock feed.

Farmers Choices

U.S. farmers currently face some difficult crop management choices- whether to plant or not to plant transgenic seeds. To date, it appears that the acreage planted to Round Up Ready® soybeans for the 2000 crop year will be similar to 1999. Round Up Ready® soybeans help farmers reduce tillage operations in many instances, provide more flexibility to spray and manage weeds, offer yields comparable to non-Round Up Ready® soybeans, and can result in cleaner fields during harvest with fewer price discounts due to foreign matter in the soybeans.



It is likely that about 55-60% of the U.S. soybean acreage will be planted to Round Up Ready® soybeans again this year. In Argentina, it is estimated that at least 70% of the soybean area is planted to Round Up Ready® varieties.

There appears to be a modest export market for non-GMO soybeans for selected Asian and European buyers. The premium will likely be 10 to 15 cents per bushel, and perhaps more for selected food grade soybeans. There are recent reports that some European buyers are contracting non-Round Up Ready® soybeans in Brazil and are paying about a 12% premium per ton.

"Strip tests" are a fairly reliable indicator as to whether a load of soybeans is Round Up Ready® or not. These tests are relatively quick and inexpensive. European buyers seem to want one percent or less "contamination" from GMO soybeans. Some Asian buyers may accept up to five percent "contamination". More accurate PCR tests take longer and cost several hundred dollars per sample.

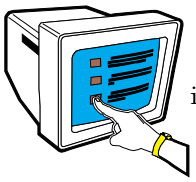
Deciding whether to plant transgenic corn for the 2000 crop year is a more difficult decision. First, there are several Bt products on the market with slightly different efficacies for European corn borer control, and thus a difference in the technology fee per unit of seed. Several herbicide-tolerant corn varieties are available such as Liberty Link® and Round Up Ready® corn. In addition, there are limited supplies of stacked genes with both the insect-resistant and herbicide-tolerant traits.

First, farmers must determine if historically there has been frequent European corn borer damage. In most of Indiana, the probability of economic damage from European corn borer is about 25% (one in every four years). In this case, the technology fee is greater than the expected returns from planting Bt corn. However, with higher expected yields and/or prices and about a 40% probability of European corn borer damage a farmer can benefit. Of course, the farmer must also take into account the economic impacts of planting a 20% refuge that may result in lower yields on that portion of the field, plus a modest amount of extra labor at planting time to change seed in the planter. (See ID-219, *Economics of Bt Corn* at http://www.agcom.Purdue.edu/AgCom/Pubs/agecon.htm#8)

Once the basic agronomic and associated economic costs and benefits have been analyzed, the farmer must also determine if there will be a market for transgenic corn in his area. For livestock feed, and some export markets, transgenic corn will be acceptable. However, some corn processors and some export buyers do not want GMO-corn. In some cases, they may pay a small premium (5 to 10 cents per bushel) for non-GMO-corn. If a farmer decides to grow both, then he must carefully segregate the crop in the field to minimize potential for pollen drift. In addition, combines, trucks, grain dryers, storage facilities, dump pits, etc. must be carefully cleaned to

avoid co-mingling of GMO and non-GMO corn. Given the expected modest premiums for non-GMO corn, each producer will need to carefully determine if the expected premium is sufficient to cover the extra labor and handling costs that he might incur to segregate his corn. The Indiana Crop Improvement Association will provide farmers with a certification service. (For more information, call (765) 523-2535 or see http://www.indianacrop.org)

Summary



Agricultural biotechnology offers considerable promise to help farmers enhance productivity, add-value through identity preserved crops, alter the composition or nutritional attributes of foods, control insects, reduce pesticide use, prevent crop and animal diseases, enhance livestock productivity and product quality, and provide novel means to produce "farmaceutical" products.

Yet, biotechnology, like many previous technologies, must be carefully managed. Refuge management will be essential with the various insect resistant crops to prevent insects from becoming resistant to the transgenic crop. Food must be carefully regulated, and, some type of science-based labeling may be necessary to assure consumers that the foods are safe and do not contain ingredients that might result in adverse health effects such as allergenicity.

Developing countries continue to seek ways to increase the productivity of their farm sector, which often operates in a harsh environment due to lack of rainfall, disease and insect pressures, or hard to manage soils. And, most of the population growth, and potential per capita income growth, is in the developing world, especially Asia and parts of Africa and Latin America. If appropriately adopted and managed, selective applications of biotechnology can help these nations improve the quantity and nutritional quality of their food supply.

The challenge is gaining public understanding and maintaining credible regulatory authorities to assure the public that the application of biotechnology will not have adverse environmental or health impacts. The key for acceptance of biotechnology will be to create regulations that the public trusts and products that deliver benefits consumers can see or taste.

Biotechnology Websites

The following websites offer a wide range of information and views on agricultural biotechnology.
http://www.agecon.purdue.edu/extensio/biotech.htm
http://www.agry.edu/com/chatchew.htm
http://www.biotech-info.net/index.html
http://www.cast.science.org/biotc_ip.htm
http://www.consumersunion.org/food/food.htm
http://vm.cfsan.fda.gov/~lrd/biotechm.html
http://www.greenpeace.org/~geneng/
http://www.extension.iastate.edu/feci/HGMO
http://ificinfo.health.org/
http://www.isb.vt.edu/
http://www.monsanto.com/
http://www.seeds.novartis.com/
http://www.pioneer.com/usa/gmo/default.htm
http://www.ucsusa.org/agriculture/index.html
Http://www.usda.gov/biotechnology/

New Ag Econ Faculty

James Pritchett

James Pritchett joined the Department of Agricultural Economics at Purdue University in October 1999 after completing a doctorate at the University of Minnesota. Pritchett's concentration of study at Minnesota included the fields of agricultural marketing, consumer economics, industrial organization, and agricultural policy.

Pritchett's primary research, extension, and teaching efforts are in grain production economics and grain product marketing with a particular emphasis in specialty grains and oilseeds. Current research includes evaluating the potential for value-added agricultural production in Indiana, investigation of specialty grain contracts, risk management opportunities in specialty crop production, consumer demand for nutraceuticals, and the economic impacts of vertical integration in the pork industry. Extension programs include beginning and intermediate agricultural marketing, the decision to plant genetically enhanced grains, and evaluation of specialty grain contracts. Pritchett teaches undergraduate grain marketing at Purdue University as well as advanced agricultural marketing to graduate students.

Originally from southeast Colorado, James Pritchett attended Colorado State University and obtained a B.S. in Agricultural Business and an M.S in Agricultural Economics from the Department of Agricultural and Resource Economics. Prior work experience includes efforts in understanding contractual relationships of livestock production, evaluating the effects of generic dairy advertising with checkoff funds, pest treatment thresholds for public grazing lands, and assessing the potential demand for new futures contracts.

The U.S. Economy, 2000: A New Track Record

Larry DeBoer, Professor

Maybe I'm too picky, but we still don't know for sure that this is the longest economic expansion in United States history. Many newspapers proclaimed that the record had been reached on February 1, 2000. True, February is the 107th month since the expansion began in March 1991, and the old record from the 1960s is 106 months. But what if a recession started in February? Then this expansion only *ties* the record. To avoid counting chickens, let's postpone the celebration until all the February data is in. By the end of March we'll know whether we're in record territory.*

The good news went on and on in 1999. Gross Domestic Product grew 4.0% above inflation, almost 6.0% over the second half of the year. The unemployment rate dropped to a 30 year low at 4.0%. Inflation increased to 2.7%, higher than in 1996 or 1997, but that was due to the oil price hikes. Take out energy prices and the inflation rate was lower in 1999 than in any year in the '90s. Interest rates increased, with the strong demand for investment funds, and rate hikes by the Federal Reserve.

Just how long can these good times roll? It's possible that this expansion can last for some time to come. The reason is low inflation.

Why No Inflation?

Inflation tends to increase when unemployment is low. The reasoning is pretty simple (maybe too simple). If workers are scarce, companies that want to expand must raise wages to fill new job openings. Higher wages attract employees from other companies, and from other pursuits like homemaking, attending school and the armed forces. To cover these higher wages, companies raise their prices. The scarcity of workers leads to faster price increases—inflation.

Not in this expansion, though. Inflation is still low after almost nine years. To see how weird this is, compare this expansion to the other long expansions since 1960. Table 1 shows the inflation rate over the first 12 months of the expansion, and over the last 12 months of the expansion, and the unemployment rate in the last month of those periods. Inflation is measured with energy prices excluded, because energy prices reflect Middle East politics as much as the scarcity of workers.

The table shows that in the 1960s, unemployment fell and inflation increased. In the 1970s, unemployment fell and inflation increased. In the 1980s, unemployment fell and inflation increased. In the 1990s, unemployment fell and *inflation fell too.* The "rule of thumb" based on the experience of previous years was that unemployment rates under 6% produced rising inflation. But unemployment has been under 6% since September 1994, and inflation is a full percentage point lower now than it was then. Economics is like that. Just when you think you know something, you don't.

What's going on? Probably, some combination of more rapid productivity increases and increased international competition. Productivity measures the amount of goods and services produced per person or machine. Productivity tends to increase when people have more and better equipment with which to work (and when machines get to work with more highly skilled people). Computers and new information technologies are the kinds of new and better machines that are probably raising productivity. With productivity increases, when labor is scarce and wages are bid upward, companies can cover higher pay with revenue from more production, not higher prices. Rising productivity tends to keep inflation down.

Competition is increasing, especially international competition for lower technology, wage-intensive goods. The share of imports in Gross Domestic Product rose from 4% in 1960, to 11% in 1990, to 14% in 1999. Companies do not feel confident enough of their customers and markets to try to pass on cost increases in higher prices. Some other firm, domestic or international, may hold the line on prices and steal the company's customers. With business information increasingly available over the internet, customers are sure to find out about the competition's lower prices, too.

Table 1. Inflation and Unemployment in Four Expansions

1960's	**Feb '62**	**Dec '69**	**Change**
Inflation	1.0	6.5	5.5
Unemployment	5.5	3.5	-2.0
1970's	**Mar '76**	**Jan '80**	**Change**
Inflation	4.9	11.8	6.9
Unemployment	7.6	6.3	-1.3
1980's	**Nov '83**	**July '90**	**Change**
Inflation	3.7	5.2	1.5
Unemployment	8.5	5.5	-3.0
1990's	**Mar '92**	**Dec '99**	**Change**
Inflation	3.4	1.9	-1.5
Unemployment	7.4	4.1	-3.3

** To be "really" picky, it will take even longer to know. A rise in inflation-adjusted GDP is the true measure of expansion, and the final GDP figures for the first quarter won't be out until June 29.*

Top Ten Expansions in United States History

Historically, expansions have not necessarily been happy times. Numbers 1, 4, 7, 8 and 9 on this list happened during wars. Number 6 happened during the Great Depression: the economy was climbing out of a very deep hole. On the plus side, expansions are getting longer. Four of the top five expansions have happened since 1960. Before then, only one peacetime expansion lasted more than four years.

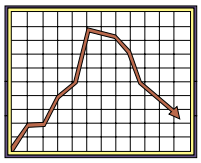
	Dates	Length in Months
1	February 1961 to December 1969	106
2	March 1991 to January 2000 (and counting)	106
3	November 1982 to July 1990	92
4	June 1938 to February 1945	80
5	March 1975 to January 1980	58
6	March 1933 to May 1937	50
7	June 1861 to April 1865	46
8	October 1949 to July 1953	45
9	December 1914 to August 1918	44
10	May 1954 to August 1957	39

Inflation and Recessions

Inflation increased during every previous expansion, and, of course, every expansion was followed by a recession. Is there a connection between rising inflation and the onset of recession? There may be, through interest rates and the Federal Reserve. The "Fed's" main job is to keep inflation under control. Its main tool is interest rates. When inflation rises, the Fed raises interest rates. This cuts borrowing, so it cuts housing construction, business investment, and consumer purchases of high priced goods. Higher interest rates may slow the stock market, which also could cut consumption and investment. Higher interest rates could raise the value of the dollar, which cuts exports and increases imports. With consumption, investment and exports down, and imports up, unemployment rises, and workers and firms find they must accept smaller pay hikes and price increases. Inflation falls.

Unfortunately, it takes many months for higher interest rates to slow the economy. And the link between the size of an interest rate hike and the amount the economy slows is uncertain. The Fed must guess future inflation from current conditions, in order to raise interest rates before inflation starts. Under these conditions, the Fed could make a mistake, raise rates too much, and slow the economy all the way into recession. If there is no inflation, the Fed need not raise interest rates significantly, so the danger of an accidental recession is less.

Sometimes a recession is no accident. From 1979 to 1982, inflation got so bad that the Fed deliberately increased interest rates so much that the economy fell into recession. If inflation is high enough, a recession may be the only solution. If there is no inflation, a recession is not needed.



The Fed's main goal is low inflation, but usually it's concerned about unemployment as well. Again, interest rates are its main tool. Lower interest rates encourage more consumption, investment and exports, which increase job opportunities and reduce unemployment. A problem is what to do when inflation is high and unemployment is rising. Should the Fed fight inflation with higher interest rates, or fight unemployment with lower interest rates? High inflation inhibits recession-fighting interest rate cuts. When there is no inflation, the Fed can feel free to cut interest rates at the first sign of trouble. That's what happened in Fall, 1998, when the Asian crisis seemed about to affect the U.S. The Fed cut interest rates and averted a crisis. Had inflation been high, perhaps they would have thought twice about interest rate cuts.

The Fed isn't the only economic policy player. Congress and the President can influence the course of unemployment and inflation through fiscal policy—changes in taxes and spending. For almost twenty years this policy avenue was blocked by large Federal budget deficits. In a recession, deficits inhibit tax cuts or spending hikes. But now, the Federal government's budget surplus is so large that fiscal policy could be used without much restraint. Taxes could be cut and government spending increased, in order to reduce unemployment.

All this means that with inflation low, the Fed has no need to create an inflation-fighting recession, is less likely to engineer an accidental recession, and can freely use its interest rate tool to fight a recession that threatens the economy anyway. With the surplus large, Congress and the President could respond to recession with tax cuts and spending hikes. Recession is less likely when inflation is low and the surplus is large.

It's a New Millennium, But. . .

Falling inflation, rapid productivity growth, and growing global trade have created a lot of excitement in business and economic circles. In its January 1, 2000 issue, a *Wall Street Journal* headline read "So long, Supply and Demand. There's a new economy out there—and it looks nothing like the old one." **

It's a new millennium, but some things probably won't change. Probably, prices will still rise and fall with changes in demand and supply. Probably, recessions still will happen. With inflation so low, there probably won't be a recession

*** The next week, another newspaper available in supermarkets, the "Weekly World News," ran this headline: "Panic! Second Great Depression by March!" At least we'll set the record.*

accidentally created by the Fed's relatively small interest rate hikes. But recessions can be caused by other shocks to the economy, too. Here are a few possibilities:

- Suppose the stock market crashes. It's happened before, sometimes with nasty consequences, as in 1929, sometimes without troubling the rest of the economy, as in 1987. Consumers and companies could respond to a crash with lower spending. Jobs would disappear, unemployment would rise, output would fall.

- Suppose there's a run on the dollar by international investors. It happened to Asia's currencies in 1997-98, and it even happened to the U.S. in the 1890s. Perhaps it could happen to our economy today, especially because we've been borrowing so much to finance our large trade deficit. Funds would be pulled out of the U.S. The Fed might raise interest rates to support the value of the dollar. Spending would fall, unemployment would rise, output would fall.

- Suppose oil prices rise even more, raising the price of gasoline to, say, double what it was at the beginning of the year. Prices doubled like that twice in the 1970s, and twice contributed to recessions. Companies facing higher costs would reduce production, lay off employees and try to pass higher costs along in higher prices. The Fed might fight these higher prices with higher interest rates. Spending would fall, unemployment would rise, output would fall.

None of these three seem very likely, though the oil price scenario seems more believable now than it did last year. But they're not called "shocks" for nothing. Events such as these are unpredictable. Still, with inflation so low, the Fed is in a better position to do something about them. And with the budget surplus so large, Congress and the President can use fiscal policy to help.

The Outlook for 2000

Alan Greenspan, perhaps the first celebrity economic policy maker, will head up the Federal Reserve for four more years. The economy is at full capacity, with very low unemployment rates, yet it continues to expand at rates above even optimistic estimates of sustainable growth. If it grows fast enough even higher productivity growth won't stop inflation from rising. The Fed has already increased interest rates this year, and will probably do so again, to try to get 4 to 6% growth down to the 3% to 3.5% range. With these rate increases, and the strong demand for funds by businesses and consumers, expect the short term Treasury rate to rise to 5.6%, and the long term Treasury rate to 6.8%, by this time next year.

There appears to be no recession in the near future. Growth might slow in 2000, if higher interest rates bite, but this may be what is needed to be sure that inflation remains under control. Expect GDP to grow 3.5% above inflation over the next year.

With productivity growing as much as it is, GDP growth of 3.5% per year should not affect the unemployment rate much. Large numbers of new employees won't be needed to produce this extra output if each employee is producing so much more. This means the unemployment rate should remain around 4.2% by the end of 2000, near where it is now. Inflation has been increasing due to oil price hikes, but there is as yet no sign of an upward trend in underlying inflation. Recent rapid growth seems likely to put some upward pressure on prices, but if growth slows to 3.5%, the increase in underlying inflation (not counting energy) should be small. Expect the inflation rate to be 2.4% over the coming year.

If all this comes true, in March 2001 we'll mark another record: a ten-year expansion.

Follow the Economy on the Web

The government agencies that provide economic statistics are on the internet in a big way. The Bureau of Labor Statistics (BLS) posts its unemployment and inflation rate press releases on the web the instant they are released. The Bureau of Economic Analysis (BEA) does the same with the Gross Domestic Product data. And the Federal Reserve has a bunch of releases on interest rates and exchange rates. Even the White House is in on the act, with an "economic statistics briefing room" that collects statistics from all the other agencies.

BLS: http://stats.bls.gov/newsrels.htm
BEA: http://www.bea.doc.gov/bea/rels.htm
Fed: http://www.bog.frb.fed.us/releases/
White House: http://www.Whitehouse.gov/fsbr/esbr.html

That's what's happening now. What's going to happen tomorrow? No one knows, but here are some intelligent guesses. The U.S. Congress' Congressional Budget Office (CBO) provides forecasts for the next ten years. If you want a second opinion for the shorter term future, try the University of Michigan's Research Seminar in Quantitative Economics (RSQE), which puts out a forecast each quarter. You also can check the Economics Illustrated Monthly Survey of Wall Street Economists. When these guys get it wrong, it costs them real money. And, our own Purdue Department of Agricultural Economics provides forecasts on the general economy and many sectors of the agricultural economy.

CBO: http://www.cbo.gov/
RSQE: http://rsqe.econ.lsa.umich.edu/
Economics Illustrated: http://www.tradestreetinv.com/html/economics_illustrated.htm
Agricultural Economics: http://www.agecon.purdue.edu/extensio/outlook.htm

The World Trade Talks: Seattle And Its Aftermath

Philip l. Paarlberg, Associate Professor

The importance of export markets to the income of U.S. farmers is clear. Recent declines in U.S. agricultural exports from $60 billion in 1996 to $49 billion currently due to increased global production and reduced foreign demand meant U.S. agriculture looked to the World Trade Organization (WTO) negotiations in Seattle to continue to expand world trade. But those talks collapsed and many farmers wonder what will be the implications for U.S. agriculture?

This article looks at the Seattle talks and speculates on the future of trade liberalization in agriculture. It begins by highlighting the difference between the image and the reality of the past Uruguay Round. Then it covers the Seattle talks and considers why those talks broke down. Finally, it speculates on the future of agricultural trade negotiations.

The Uruguay Round: Image versus Reality

The events in Seattle really begin in the Uruguay Round completed earlier in the 1990s. That round of multilateral trade negotiations made many positive accomplishments for U.S. agriculture. Yet, there was a great difference between the image of what was achieved and the reality.

The image was that non-tariff barriers were to be converted to tariffs and reduced by 36 percent in developed countries and 24 percent in developing countries. The variable levy of the European Union was abolished. No new export subsidies were allowed and existing export subsidies were to be cut on a volume basis by 21 percent and on a value basis by 36 percent. Domestic farm programs were on the negotiating table and the aggregate measure of support was to be lowered by 20 percent. Technical, sanitary, and phytosanitary barriers to trade were to recognize an acceptable risk and to be based on science. Dispute settlement procedures were strengthened.

The reality was that these accomplishments were subject to exceptions that undercut the effectiveness of the agreement. Within the rules of calculating tariffs and tariff equivalents countries could use price data that inflated the tariff ceilings beyond the level of the actual tariff. Thus, even after the Uruguay Round reductions many of these inflated tariff ceilings were higher than the actual tariffs imposed. While the European Union's variable levy was prohibited, the European Union (EU) could calculate a tariff equivalent high enough to allow it to run a fluctuating tariff. Presently the EU tariff changes at least every two weeks, making it function like a variable levy.

Negotiators, aware that nations could avoid liberalizing trade policies, imposed minimum access rules using a new policy, the tariff-rate quota. In theory, the quota marks the difference between a low and high tariff. In practice, it can be used to operate an import quota, just like before the negotiations. Some issues, like export credit programs and state trading, were put off for later negotiations.

Implementation problems arose with the requirement that technical and health trade barriers be based on science because science is not always clear cut and independent of political pressures. Developing countries felt that developed nations have used technical and health barriers instead of tariffs and quotas to continue to exclude their products. The new dispute mechanism had problems as well. The idea was that under the new Uruguay Round rules one nation could not block an adverse judgment. However in two important cases, bananas and beef, the European Union has chosen to ignore the WTO rulings.

Aware that there would be implementation problems, the Uruguay Round negotiators added a mandate to conduct more negotiations for agriculture and services beginning in the year 2000. That provision required a meeting by the end of 1999, which is what led to the meeting in Seattle.

In Seattle

While negotiations for agriculture were required under the Uruguay Round, the task confronting negotiators in Seattle was to develop an agenda for the talks. Would the next talks be confined to the specific areas laid out in the Uruguay Round or would they be broader? Agricultural interests in the United States were in favor of broad negotiations that would allow the trade-offs among sectors which had helped bring the Uruguay Round to an agreement. Agricultural interests feared that countries not wanting further agricultural liberalization would paralyze the talks if there were not other areas where they could benefit. Ironically the European Union, which the United States believed did not wish to liberalize agriculture further, also wanted broader negotiations, including inclusion of environmental issues and labor rights. Other nations, many of them developing nations, sought more narrowly defined negotiations. Placing labor standards and environmental issues in the negotiations was seen as disguised protection by developed nations.

The Seattle talks were ministerial talks where trade ministers represented their nations. In normal situations trade ministers come together to work out the details after the majority of the text has been agreed upon. This did not happen in Seattle. Prior to the Seattle ministerial there was no draft text with most of the issues resolved. One reason for the lack of an agreed text was that the top WTO staff was inexperienced since many had been appointed only shortly before the meeting. Also the climate supporting the negotiations

was poorer than that in the Uruguay Round. Neither the United States nor the European Union had strong advocates for another round. In the Uruguay Round U.S. farm and business interests were strongly behind the negotiations with labor interests opposed, but weak. At Seattle the roles were reversed. Partly this reflected the increase in regional trade agreements that generated many of the benefits anticipated in a multilateral negotiation. Partly it reflected the gains made in the Uruguay Round. The European Union's attention was also diverted to other issues, eastern expansion, farm policy reform, and regional trade agreements.

Another feature of past trade negotiations was that the big players: the United States, the European Union, and Japan, usually cut a deal among themselves, and then presented it to the other members for them to accept. This was the case in the Uruguay Round where little progress was made until the United States and the European Union came to a separate agreement on farm issues, the Blair House agreement. Once that happened the Uruguay Round was quickly wrapped up. In contrast, in Seattle developing countries were not willing to play this game. They had been left sitting on the bench during the Uruguay Round game. Threats by the United States to convene a smaller group of nations to hammer out a deal produced a backlash of anger.

A serious problem in Seattle was the debate over including labor rights and environmental issues in the negotiations.

Environmental groups believe that several WTO decisions have undercut the rights of nations to enact laws protecting the environment. Groups also worry that encouraging trade promotes the exploitation of labor in developing nations while causing job losses in developed nations. These groups and others took to the streets in an effort to stop the meetings. The street demonstrators cannot be given credit for the collapse of the talks, but they were certainly disruptive and made difficult negotiations more difficult. When the U.S. President appeared to side with the concerns of the demonstrators, developing country representatives were appalled. They saw the effort to place labor and environmental concerns on the agenda as an attack on their chances for economic growth.

Prior to the actual meetings in Seattle agriculture was seen as having the potential to wreck the negotiations. In the end that was not the case. While agricultural differences were not resolved, progress was being made as the meeting collapsed. It appears that the immediate causes of the failure in Seattle came from other forces, the lack of a solid draft text, the insistence of the United States to play by the old rules, and the unwillingness of developing countries to do so, and the drive by the United States and the European Union to broaden the negotiation to include labor and environmental issues.

What is Next?

In the aftermath of the debacle in Seattle a critical question for U.S. agriculture is what happens now? Does the collapse in Seattle result in the end of efforts to liberalize agricultural trade? Or is this only a delay as has occurred before?

There are reasons to believe that Seattle represents only a delay. Within a month of the collapse the United States and the European Union had pledged not to walk away from the negotiating table. They formed two working groups to discuss the troublesome issue of trade in genetically modified organisms (GMOs). A biosafety protocol was negotiated in Montreal Canada during January which includes GMOs. The United States and the European Union disagree on much, including whether the commitments made in Seattle are still binding, but neither appears willing to scuttle the negotiations.

At the same time there are concerns that efforts to further liberalize agricultural trade have been dealt a serious blow. It is hard to see how negotiations on only agriculture can progress. President Clinton does not have "Fast Track" negotiating authority, and it appears unlikely he will get it from Congress. Election years do not usually lead to bold policies. It is hard to see progress occurring if the United States continues to link trade liberalization negotiations to labor rights and environmental issues. The absence of "Fast Track" authority illustrates the lack of support in the United States for further multilateral trade negotiations.

"In the aftermath of the debacle in Seattle a critical question for U.S. agriculture is what happens now? "

How these forces will play out is pure speculation at this point. I expect the United States and the European Union to continue their bilateral discussions on agriculture, but the speed of progress will largely be determined by how fast the European Union can reform its own farm policies. As the European Union negotiates over the membership of nations in Central and Eastern Europe, pressures for internal farm policy reform will build. These forces will be resisted by EU farmers fearing a reduction in subsidies in a world market with depressed agricultural prices. By the summer of 2001, with a new U.S. President, we will have a better sense of whether the failure in Seattle was an end or a delay. Much will depend on whether farm and business groups can re-kindle the support needed to counter interests opposed to further trade liberalization.

Financial Performance: Measurement and Analysis

Craig Dobbins, Professor; Michael Boehlje, Professor; Alan Miller, Farm Business Management Specialist; and Freddie Barnard, Professor

One task of a farm business manager is measuring and analyzing financial performance. To successfully accomplish this task, the farm business manager must decide how the evaluation will be conducted, collect data that accurately reflects actual performance of the business, and develop a set of standards or benchmarks for measuring performance. If performance is not satisfactory, the manager must make adjustments that will lead to improved performance.

What is the financial position of my farm business? Do I have the financial capacity to weather a period of low prices? Am I headed for financial trouble or have I made good financial progress? How does my financial position compare with others? These are questions that many farm business managers are asking today.

This article provides worksheets that will be helpful aids for identifying and organizing data for the measurement of financial performance. To conduct a financial assessment of your business you will need data that measure annual receipts and expenses (Internal Revenue Service Schedule F and Form 4797), and balance sheets that correspond to the beginning and ending of your tax year. Using these items, it is possible to complete the financial assessment with very little additional work.

What should I look for?

In assessing the financial position of a farm business many analysts begin with a brief financial description. This financial description includes six items:

1. Total assets
Total assets represent the market value of all financial and capital resources owned by the business at the time of balance sheet preparation. Total assets indicate the size of the business' financial resources in terms of overall capacity.

2. Total liabilities
Total liabilities measure the value of total debt obligations at the time of balance sheet preparation. Total liabilities indicate the financial claims of lenders, input suppliers, and others on the business.

3. Owner equity
Owner equity measures the value of the owners' claims on total assets. It is determined by subtracting total liabilities from total assets and often is referred to as net worth. Owner equity indicates the owners' financial stake in the business–their financial commitment to the business.

4. Gross revenues
Gross revenues measure the total value of products produced by the business. To improve the accuracy of this measure, it is best that gross revenues for the year be expressed on an accrual or accrual-adjusted basis (i.e., whether sold for cash or held in inventory). Gross revenue indicates the income from sales and other farm income sources available annually to cover expenses, principal payments, family living, income taxes, expansion, etc.

5. Total expenses
Total expenses measure the total of fixed and variable expenses incurred during the year as measured by the accrual-adjusted income statement. Total expenses indicate the total costs incurred in producing gross revenues.

6. Net farm income
Net farm income measures the net income available on an accrual-adjusted basis after fixed and variable expenses have been deducted. This is a basic measure of the profitability for the farm operation. For the sole proprietor form of business, net farm income indicates the amount of income available for family living, income taxes, capital investments, etc. In order to make financial progress from business operations, net income must exceed the owner withdrawals for family living and income taxes.

Table 1 summarizes common financial performance measures used by analysts and lenders, indicates what they mean, and provides values that can be used in benchmarking.

What is benchmarking, and what are benchmarks? Benchmarking refers to the practice of looking for those businesses that are the best at doing something and learning how they do it in order to emulate that performance. Financial benchmarking involves looking for actual performance data from farms that are comparable to your own. Financial benchmarking oftentimes provides crucial evidence for answering the question, "How should my farm be doing if it is going to be competitive in the farming industry?"

Ratios rather than absolute financial measures are often used for benchmarking. Ratios present financial information in the form of a relative relationship between two absolute measures of performance. This removes the influence that business size has on the measure, making ratios easier to compare and interpret than absolute measures.

For example, liquidity can be measured by working capital (current assets minus current liabilities), but in order to know if the amount of working capital is adequate, the size of the farm must be known. It is difficult to make comparisons among farms because of the differences in size. In Table 1, we suggest measuring liquidity using the current ratio (current assets÷current liabilities). Because these two measures are now compared in the form of a relative relationship, adjustments for size are not necessary, and more meaningful comparisons across farms of different sizes can be made. The use of

Table 1. Key Financial Performance Measures[1]

	Measure	Interpretation	Benchmark	
			Average	High Profit
Profitability				
Operating Profit Margin	Calculated as net income plus interest expense minus family living and income taxes divided by gross revenues.	The proportion of earnings or revenues that is operating profit and thus available to compensate debt and equity capital. Indicates the operating margins and reflects the ability to generate revenues and control costs in such a way as to generate a profit.	16%	32%
Return on Assets (ROA)	The net income plus interest expense minus family living and income taxes divided by total assets.	An index measurement of profitability that indicates the profitability per dollar of assets, thus allowing comparisons over different size firms and different types of businesses or investments.	7%	14%
Return on Equity (ROE)	The net income after all labor and interest charges. That is, the residual return to the owner's investment divided by the equity investment.	An index measurement of the return the owner of the business receives on his/her money invested. Can be compared to rates of return in other investment opportunities such as stocks, bonds, or savings accounts. The rate of return on equity needs to be larger than the rate of return on assets for borrowing to be advantageous to the business.	6%	18%
Liquidity				
Current Ratio	Calculated as current assets (inventories, cash, accounts receivable, etc.) divided by current liabilities (operating loan payments, accounts payable, unpaid taxes due, this year's principal payments on term loans, accrued interest and rent, etc.).	A basic indicator of short-term debt servicing and/or cash flow capacity. It indicates the extent to which current assets, when liquidated, will cover current obligations. It does not predict the timing of cash flows during the year or the adequacy of future revenue inflows in relation to outflows.	3.1	3.3
Solvency				
Debt-to-Asset Ratio	Total liabilities divided by total assets.	The basic leverage of the business, (i.e., what proportion of total farm assets is owed to creditors). Measures the ability of the business to repay all financial obligations if all assets were sold.	32%	26%
Financial Efficiency				
Asset Turnover Ratio	Gross revenues divided by total assets.	Reflects how efficiently farm assets generate revenues, indicates the volume of business generated by the asset base (i.e., the flow of revenue through the asset pipeline). Can show wide variation depending on the proportion of owned land or other assets.	35%	43%
Revenue per Full-Time Employee (FTE)	Gross revenue divided by the person years of labor (both operator and hired) used in the farming operation.	The fundamental measure of labor efficiency; reflects how productive labor is and whether or not it is fully employed.	$227,518	NA
Operating Expense Ratio	Total operating expenses minus depreciation divided by gross revenue.	The proportion of total revenues that are absorbed by operating expenses.	63%	52%
Depreciation Expense	Depreciation expense divided by gross revenue.	The proportion of total revenues that are absorbed by depreciation expense.	8%	7%
Interest Expense Ratio	Total farm interest expense divided by gross revenue.	The proportion of total revenues that are absorbed by interest expense.	8%	6%
Net Income Ratio	Net farm income divided by gross revenue	The proportion of total revenue that remains as net income after all expenses are paid.	20%	37%

1 Benchmarks are from Edwards, William. "Interpreting Financial Performance Measures," Ag Decision Maker, File C3-56, November 1998. These benchmarks were developed from data for the years 1990 to 1996.

relative relationships also allows comparisons to be made for the same farm for several different years.

What calculations are needed?

Assessing the financial condition of a farm business requires information from a balance sheet and an income statement. Most farmers have a balance sheet, particularly if they borrow money since this document is a standard requirement of the credit transaction. Some farmers will have quite complete income statements based on an accrual accounting system, but many will only have a Schedule F tax return to provide evidence of their income generating capacity. Even with this limited information, you can complete a relatively accurate financial analysis including the key performance measures identified in Table 1.

You can use Worksheet 1 to organize the appropriate input information. One of the virtues of this worksheet is that you should already have most of the required data, once you have filed your income tax return. This worksheet will help you obtain the best estimates possible of key financial performance ratios with a limited amount of readily available data.

In order for the worksheets to generate accurate accrual-adjusted financial measures, the beginning and ending balance sheet dates should fall within a few days of the

Worksheet 1. Input Information

Schedule F Data **Taxable Year:**		
Cost of livestock sold (Schedule F line 2)	(a)	
Gross income (Schedule F line 11)	(b)	
Depreciation (Schedule F line 16)	(c)	
Mortgage interest (Schedule F line 23a)	(d)	
Other interest paid (Schedule F line 23b)	(e)	
Total expenses (Schedule F line 35)	(f)	

Balance Sheet	Beginning		Ending	
Balance sheet date				
Cash	(g)		(l)	
Total current farm assets	(h)		(m)	
Total current farm liabilities	(i)		(n)	
Accrued interest	(j)		(o)	
Farm accounts payable and accrued expenses.	(k)		(p)	
Total farm assets			(q)	
Total farm liabilities			(r)	
Owner's equity			(s)	

Miscellaneous Data		
Breeding stock sales (Form 4797)	(t)	
Number of operators and employees (annual, full-time equiv.)	(u)	
Family living expense (all families supported by the farm)[2]	(v)	

Net Farm Income		
Gross revenues [a+b+t+(m-l) – (h-g)]	(w)	
Interest expense [d+e+(o-j)]	(x)	
Other expenses [f-(d+e)+(p-k)]	(y)	
Net farm income [w-x-y]	(z)	

2 This number is used to approximate the value of unpaid family and operator labor. University of Illinois research indicates that 1997 total living expenses for 1-2 member families is $39,332; 3-5 member families is $47,950; and 6+ member families is $47,083. Do not include a value here if the operator and family members are paid a reasonable wage by the business and those wages are already included in the value on line f.

beginning and ending dates, respectively, for a farmer's taxable year. For example, March 1 balance sheets would produce unreliable measures when combined with a calendar year Schedule F.

Worksheet 1 identifies where specifically to look for the necessary information in the federal income tax return and what type of information to input from beginning and ending year balance sheets. Worksheet 2 guides you through a series of specific computations using the data from Worksheet 1. The computations required by Worksheet 2 produce values for the key financial measures outlined in Table 1. Once these measures have been computed, you can transfer the high-profit benchmarks from Table 1 to the benchmark column on Worksheet 2. Finally, you should compare the values for each of the financial measures to the corresponding benchmark in order to assess the financial performance and financial position of your farm.

How do you measure up?

Indications of financial strength will depend on the measure being considered. In some cases, a measure with a value greater than the benchmark will indicate financial strength. In other cases, a value smaller than the benchmark will indicate financial strength. Table 2 indicates which measures fall into which categories.

At a very minimum, your farm needs to perform better than the average of farms that are similar to your own. The average benchmark provides a reference point for recognizing better-than-average performance. More likely than not, that level of performance will not be good enough long term, and so producers should benchmark against the top

Worksheet 2. Financial Performance Measures

Measure	Your Farm	Bench mark	Strong(+)/Weak(-)[3]
Profitability			(Circle one)
1. Return on Assets	_____ %	_____ %	+ -
[(z+x-v)÷q] x 100			
2. Return on Equity	_____ %	_____ %	+ -
[(z-v)÷s] x 100			
3. Operating Profit Margin	_____ %	_____ %	+ -
[(z+x-v)÷w] x 100			
Liquidity			
4. Current Ratio	_____	_____	+ -
[m÷n]			
Solvency			
5. Debt-to-Asset Ratio	_____ %	_____ %	+ -
[r÷q] x 100			
Financial Efficiency			
6. Asset Turnover Ratio	_____ %	_____ %	+ -
[w÷q] x 100			
7. Revenue per Full-Time Laborer	_____	_____	+ -
[w÷u]			
8. Operating Expense Ratio	_____ %	_____ %	+ -
[(y-c)÷w] x 100			
9. Depreciation Expense Ratio	_____ %	_____ %	+ -
[c÷w] x 100			
10. Interest Expense Ratio	_____ %	_____ %	+ -
[x÷w] x 100			
11. Net Farm Income Ratio	_____ %	_____ %	+ -
[z÷w] x 100			

3 A strong indicator for items 1, 2, 3, 4, 6, 7, and 11 would be a value for your farm that is greater than the benchmark. A strong indicator for items 5, 8, 9, and 10 would be a value for your farm that is less than the benchmark.

performing or so-called "high-profit" farms, whenever they are establishing performance standards or targets for their farms. Benchmarks of this type should at least be in your sights, even if your own measures indicate that you are currently falling short of the mark.

Farm business managers have several alternatives available for setting performance standards or benchmarks. Generally, it is important to assess your current performance relative to performance in prior years. This can often lead to valuable insights into trends in business performance. It is also important to try to control financial performance by projecting expected values for the key performance measures for your farm. These projections can then be used to systematically evaluate variations between planned performance and actual performance. The reasons for differences between actual and expected performance need to be determined. In some cases, the differences will indicate adjustments are needed. While both of these inward-looking approaches to assessing business performance are useful, neither tells management much about farm competitiveness. In order to feel comfortable that the farm is competitive, you need to look at how other similar farms in the farming industry are performing.

Financial benchmarks for farms are almost always derived by averaging the actual performance data from a large group of farms. The high-profit benchmarks are typically derived by selecting the one-fourth or one-third of the farms in that large group that are the most profitable and averaging the financial performance measures from those farms. Farm Business Associations in Illinois, Iowa, and other midwestern states are important sources of such data. Often, these associations work with enough farms that they can sort farms into different groups based on differences in size, major enterprises, etc. This allows the producer who is looking for appropriate financial benchmarks to choose benchmarks from farms that are very similar to his or her own farm.

Make an effort to know as much as possible about the source of the benchmarks against which you plan to measure your farm's performance. Some benchmarks are highly variable in terms of what constitutes top performance based on factors such as the type of farm commodities produced. For example, gross revenue per person on a high-profit dairy or swine farrow-to-finish operation typically will be lower than for high-profit cash-grain farms.

Also, other factors, such as the time period over which the performance information was gathered, will influence the values for certain measures. Even methods used to summarize income, expenses, assets, and liabilities can have a big impact on the reliability, consistency, and comparability of the resulting measures. For example, the value of farm production is a popular alternative to gross farm income for computing financial efficiency measures in some areas of the country. These two alternative measures of farm revenues can produce significantly different values for financial efficiency measures on a farm with significant feed and/or feeder livestock purchases. Furthermore, the value of farm production tends to be computed in several different ways. It's essential to know where the benchmarks come from, how the raw farm data was summarized, and how the benchmarks were calculated before you rely on them.

A web site that provides links to benchmark data from selected farm business associations is available at www.agecon.purdue.edu/extensio/finance. The benchmarks provided in Table 1 provide representative benchmarks for general farm types for the period of 1990-1996. Data available through the web site provide benchmarks for specific types of farms and for specific years.

Assessing strengths and weaknesses is the first step in the analysis process. Next, consider why particular measures turned out the way they did. That is, make sure you can identify and understand the causes of better than average as well as poorer than average performance measures. Finally, think about how to build on strengths and correct weaknesses.

In the last column of Worksheet 2, circle the plus or minus, as appropriate, to assess the financial strengths and weaknesses of your farm relative to the benchmark farms.

Table 2. Indicators of Financial Strength

Values Larger Than Benchmark	Values Smaller Than Benchmark
Return on assets	Debt-to-Asset ratio
Return on equity	Operating expense ratio
Operating profit margin	Depreciation expense ratio
Current ratio	Interest expense ratio
Asset turnover ratio	
Revenue per full-time person	
Net farm income ratio	

A Final Comment

The information and worksheets in this article will help you measure and analyze the financial position of your farm business. We encourage you to make copies of the worksheets and use them annually. While analysis for any one year can provide you with useful insights, the trends that you will uncover through annual use of the worksheets will provide you with increasingly valuable information.

To further aid your analysis, an Excel spreadsheet of these worksheets is available at www.agecon.purdue.edu/extensio/finance.

Additional information on farm financial analysis is available in *Measuring & Analyzing Farm Financial Performance* (EC-712). Copies of this publication can be ordered from MDC, 301 South 2nd Street, Lafayette, IN 47901-1232. Individual copies are $10.

Economists See Improvements for Some Sectors of Indiana Farm Economy.*

After difficult years in both 1998 and 1999, some sectors of the Indiana agricultural economy are expected to improve in 2000. The livestock sector, led by stronger prices for both cattle and hogs will have favorable profits. Diary however, will weaken. Income from crops could improve in 2000. Yields in 1999 were depressed with corn about 3 bushels below trend and soybeans 4 bushels below. Corn prices will move back above loan levels which could further help improve incomes, but both wheat and soybeans will see prices stay below loans. Government financial assistance is also expected to remain strong. In sum, farm incomes are expected to show some increase over 1999.

Trade

World agricultural markets continued to be plagued by large food supplies and the lingering effects of Asian financial problems. Agricultural exports by the United States are forecast at $49.5 billion, just $500 million above last fiscal year. Imports of agricultural commodities are forecast at $38 billion compared to $37.5 billion last year. Prices for major agricultural commodities are expected to remain weak.

Although the United States and China agreed to a trade deal which opens the Chinese market for agricultural goods and paves the way for China to join the WTO, that deal has not been approved by Congress. Hanging over U.S. agricultural trade is the rising resistance to GMO products.

Policy

Despite a record $22 billion dollars in government expenditures for agriculture this last year, more government assistance is likely on tap for 2000. With poor economic conditions being projected for agriculture, even the most conservative of economists expects the government to step in with emergency assistance for the third consecutive year. Recent projections have farm income projected at $40.8 billion dollars for 2000, which is down nearly $8 billion dollars from last year. Couple this with coming elections and it appears there is at least a 75% chance of some form of additional government income assistance in the coming year.

Improved Prospects for Corn, but Not Soybeans

The corn market is expected to have improving prices in 2000. Corn use will reach record levels for the 1999-2000 marketing year at 9.5 billion bushels. Domestic use is very favorable with strong use for feed and ethanol production. Exports are up11% in early March. Carryover stocks will likely drop to somewhat over 1.6 billion bushels by the end of August 2000.

Corn prices are expected to recover somewhat into the spring with central Indiana prices in the $2.00 to $2.20 level. The price direction into the summer will be greatly influenced by weather conditions with the possibility that prices could move back under $2.00 with favorable weather and with large volumes of corn coming off loan in the summer.

With normal weather, this years crop is expected to be 9.4 billion bushels which will be about 300 million bushels below use, and thus carryover stocks could drop to about 1.3-1.4 billion bushels by August 2001. Given a normal weather situation, cash prices at harvest are expected to be in the $1.75 to $1.95 range in central Indiana, with LDP's ranging from 0 to 20 cents per bushel. Spring new-crop forward pricing should be considered with cash contract prices in the $2.30 to $2.40 range. Indiana prices (with normal weather) for the 2000 crop are expected to average about $2.20 per bushel, 20 cents higher than the 1999 crop.

Dry subsoil conditions remain prevalent throughout the Midwest this spring and increase the odds for reductions in yields.

While corn is expected to trade above loan levels for much of the year, soybean prices will likely stay below loan. Planted acreage is expected to reach new records this year as the government soybean loan tends to be more favorable than similar guarantees for corn. Old crop soybeans are expected to trade in a range of $4.75 to $5.10 this spring. Summer prices will be highly influenced by summer weather conditions with favorable growing weather pushing soybean prices, perhaps back to the $4.50 level. Alternatively, weather concerns could cause prices to move higher into the summer. As with corn, there is great uncertainty for those who store into mid-to-late summer.

With record soybean acreage and normal summer weather, the 2000 harvest will exceed 2.8 billion bushels and result in growing carryout prospects, and lower prices. With normal weather look for harvest prices in central Indiana to be in the $4.50 to $4.75 range with LDP's of 70 to 95 cents per bushel. In general, most will *not* want to forward price new-crop soybeans below the loan rate until spring and summer weather patterns become more clear.

** (Contributors include: Mike Boehlje, Larry DeBoer, Craig Dobbins, Otto Doering, Howard Doster, Allan Gray, Chris Hurt, Phil Paarlberg, James Pritchett, Lee Schrader, and Joe Uhl)*

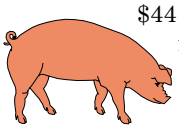
Cattle Look Great, Hogs Back to Profits

Cattle prices are expected to strengthen throughout the year. Choice steer prices averaged $64 in 1999 and will surge to $70 this year. Feeder cattle and calf prices will also be strong. Steer calves (500-550 pounds) averaged about $86 in 1999, but will reach near $1 per pound in 2000. The strong prices are a result of 2% to 3% lower supplies and strong domestic demand as a result of the favorable general economy and the popular "high protein diet."

Finished cattle prices are expected to peak in the early spring in the low $70s. Prices will move slightly lower in the summer, perhaps back into the higher $60s, with the strongest prices of the year coming in the fall with $72 to $74 prices possible.

At least two factors will pose threats to a favorable profit year for producers. The first is the prospect of continued drought in Texas and the Southwest. The second threat to the cattle industry is higher interest rates. Higher interest rates will cut into cattle feeding margins and result in lower bids for feeder cattle and calves as well as slowing economic growth.

Hog prices should average $42 to $44 for the year, a sharp increase from the $34 of 1999. Difficult financial times in 1998 and 1999 have resulted in the breeding herd being cut 7%, with 4% fewer market hogs. Prices are expected to move sharply higher in late-April and May reaching $45 to $46 in the summer. Only modest declines are expected in the fall, with prices in the $42 to $44 range. The breeding herd is not expected to move back toward expansion until late in the year. If so, this means that pork supplies will continue to move lower into the first-half of 2001.



The greatest threat to hog producer profits for 2000 seem to be dry weather concerns and the possibility of higher feed prices. For this reason, producers should consider covering a portion of their feeding needs by buying corn and meal futures or call options.

Land Values and Cash Rents

The *June 1999 Purdue Land Value Survey* indicated that for much of the state, the steady increase in land values had paused. On a state wide basis, top, average, and poor land was estimated to have a value of $2,643, $2,092, and $1,546, respectively. Compared to year-earlier values, this was a decline of 2.7%, 2.9%, and 5.3%, respectively for top, average, and poor land.

A land value survey conducted by the Federal Reserve Bank of Chicago reported steady increased value in Indiana during the last quarter of 1999.

For 2000, interest rates will likely rise more, putting downward pressure on land values. In addition, soybean and wheat prices will likely stay below loan values. Some potential income improvement can be expended from corn as well as hogs and cattle. Thus land values are expected to remain fairly steady to down somewhat.

On a state wide basis, cash rent for top, average, and poor quality farmland was estimated to be $138, $110, and $84 per acre, respectively. Compared to year-earlier values, this was a decline of 1.4%, 1.8%, and 2.3%, respectively for top, average, and poor quality farmland.

The current economic situation should continue to put downward pressure on cash rents. However, there also continues to be strong competition for rented farmland. While many tenants have approached landowners about reducing cash rents, reaching such an agreement is often difficult. It is expected that cash rents for 2000 will be 0% - 3% less than rents in 1999.

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