Perceptions of Iowa agricultural extension agents regarding agricultural biotechnology training and informational needs

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CHAPTER I. INTRODUCTION

Agricultural biotechnology will have a major impact on production agriculture in the U.S. and throughout the world (Committee on a National Study for Biotechnology in Agriculture, 1987). American farmers, agribusiness, and the consumer will play a key role in deciding which new agricultural biotechnologies are utilized in modern agriculture. Additionally, the Cooperative Extension Service will be involved in the applied research of agricultural biotechnologies, technology transfer, and dissemination of information to the agricultural sector, and perhaps most importantly, educating the public and dealing with their perceptions towards these new technologies.

Problem

The study of the biotechnologies has moved to the forefront in recent years, resulting in new innovations that have the potential to impact agriculture. According to McKean (1990), the emergence of bio-engineering production processes has made compounds readily available that previously had been too expensive. He added that compounds such as growth hormones have significant capabilities to increase productive efficiency, as well as provide significant economic gains for early adopters. Several agricultural areas will be impacted by biotechnology, as scientists and researchers have discovered ways to manipulate genes, including splicing and splitting; studied various biological pest controls; utilized new growth enhancers in swine research; all of which have implications to production agriculture.

The adoption of new technologies can be very important to agriculture and its producers. Ritchie (1990) suggests that with new technology, the early adopters reap the benefits of increased return, and producers who do not adopt become financially less competitive. Extension has been involved with innovation adoption for quite some time. Studies need to be conducted which focus on helping develop educational programs directed at farm operators. These educational programs should be designed to help farm operators determine the feasibility of the biotechnologies to their operations, and eventually the adoption of certain aspects of biotechnology that fit into their specific management schemes.

The study of technology transfer in agriculture has received attention from many researchers in agricultural and extension education. The focus of some researchers has been directed at the adoption and diffusion process in regard to new innovations.

A study by Kamga and Cheek (1986) which involved 413 cocoa farmers concluded that there is a relationship between knowledge and the adoption of recommended practices. Another study by Pontius (1980) also found a relationship between rate of adoption and awareness of new innovations when working with farmers in four villages in Thailand. Pontius also theorized from his work with these farmers that access to persons or sources who possess the knowledge necessary to evaluate new technology influences the rate of adoption, and early adopters set a precedent for the later adopters. These studies imply that knowledge is vital in the adoption process, and that early adopters will influence later adopters, thus indicating that education is necessary in the adoption process and

should be targeted as "early adopters." According to Hoban (1989), new biotechnologies will be adopted more rapidly than previous agricultural technologies because farmers now are more knowledgeable. He also pointed out that better communication and technology transfer systems exist. He further implied that the Extension Service should have a role in the technology transfer process and in applied research.

Need for the Study

Agriculture will continue to feel the impact of new technologies and innovations. American agriculture will need to continue to improve its competitive edge by increasing efficiency in food and fiber production (Clarke, 1986). Clarke further suggested that "agriculture needs a new infusion of science and technology and new capabilities that will restore and enhance competitiveness of U.S. agriculture in the world marketplace" (p. 37). American farmers must continue to look for ways to produce agricultural products as efficiently as possible, while maintaining quality of those products (Committee on a National Strategy for Biotechnology in Agriculture, 1982). It is important for educators to understand the adoption process, and be able to identify factors that influence this process. Educators can better target educational program efforts to aid in technology transfer if it is known which types of farm operators are more likely to be seeking information on new technologies (Kamga & Cheek, 1986).

Biotechnology has the potential to alter and change several production practices and systems. It is important that educators are aware of the attitudes and perceptions that farm operators have towards

the new biotechnologies, and the interest level in obtaining more information about these innovations, as well as being informed themselves regarding innovations resulting from biotechnology.

Purpose of the Study

This study is an attempt to identify perceptions held by Agricultural Extension Agents in Iowa regarding various aspects of agricultural biotechnology. The purpose of this study is to identify topical areas in agricultural biotechnologies in which there is a need for training. Additionally, the study seeks to measure the degree to which informational material is needed by Agricultural Extension Agents. The results of this investigation will provide useful information to Extension program leaders and staff as to in-service training needs of field staff, as well as provide an indication as to the type of informational material to be developed.

If the Cooperative Extension Service is to play a role in education concerning agricultural biotechnology, certain informational and educational needs must be met for Agricultural Extension Agents. The following questions were considered appropriate for this study:

1. To what extent is training needed in various selected topical areas of biotechnology?
2. To what degree is it felt that informational material is needed?
3. What perceived differences exist in regard to bioethics, biotechnology's potential impact on agriculture, and

Extension's role in biotechnology education among Agricultural Extension Agents?

4. What perceived comparisons exist in regard to bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education according to selected demographic features?

The overall purpose of this study was to identify the perceptions of Agricultural Extension Agents in Iowa regarding training and informational needs relating to agricultural biotechnology, as well as perceptions towards bioethics, biotechnology's potential impact on agriculture, and Extension's role in education concerning biotechnology.

Objectives

The specific objectives of this study were:

1. To identify the level of importance of agricultural biotechnology as perceived by Agricultural Extension Agents in Iowa.
2. To determine the extent of training needed as perceived by Agricultural Extension Agents in Iowa regarding various topical areas in biotechnology.
3. To determine the degree of importance relating to informational material needed by Agricultural Extension Agents in Iowa regarding various topical areas in biotechnology.
4. To identify perceptions held by Agricultural Extension Agents in Iowa in regard to bioethics, biotechnology's potential

impact on agriculture, and Extension's role in biotechnology education in the agricultural and public sectors.

5. To compare perceived differences existing in Agricultural Extension Agents in Iowa regarding agricultural biotechnology according to various demographic factors.

Operational Definitions

Agricultural Extension Agent: A person employed by a Land Grant University responsible for extending research-based information and providing educational programs relating to agriculture to the citizens of the state, authorized by legislation including the Smith-Hughes Act of 1917.

Biotechnology: The application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services (Martin, 1987).

Bioethics: The attention to the socio-economical, ethical, or environmental implications of biotechnology.

Iowa Extension Areas: The seven geographical areas in Iowa comprised of 13 to 16 counties that serve as administrative areas and are referred to as Northeast, North Central, Northwest, Southwest, Central, East Central, and Southeast.

Level of agreement in need for training: The level to which Agricultural Extension Agents perceive there is a need for training in various topical areas of biotechnology, specifically in relation to in-service training needs in order to develop competencies in biotechnology topics directed related to agriculture.

Level of agreement in need for informational material: The level to which Agricultural Extension Agents perceive there is a need for informational material in various topical areas of biotechnology, specifically in relation to research data, product information, sources of further information, and publications or literature to use as reference material.

Innovation: Something newly introduced or created such as a new method or device.

Adoption of technology: A component of the process of change. This study primarily referred to adoption by farmers of new methods, products, or devices developed by researches, agribusiness, and producers themselves and occurs at varying rates by individuals.

Technology transfer: The process of gathering and utilizing information associated with new innovations. It is used in the decision-making process concerning utilizing new innovations by using information, and refers to the application of knowledge and development of skills to use technology.

Information dissemination: The spreading of information, and in the case of the Cooperative Extension Service, extending information from researchers and educators at the university to people throughout the state.

Implications and Educational Significance

The study has implications to Extension Agricultural Agents and agriculture in general as biotechnology moves out of its infancy stage as more research and studies are conducted and innovations are produced.

This study provided an indication as to the importance Agricultural Extension Agents place on biotechnology in general, but particularly how they perceive their involvement in the educational process concerning biotechnology. Historically, the Cooperative Extension Service has been involved with extending unbiased research-based information to citizens in the state. The field of biotechnology provides another opportunity to meet the educational needs of agriculture clientele, as well as the general public.

Even though educational leaders in agriculture have differing views as to the role the Cooperative Extension Service will play in education concerning biotechnology, it was generally felt that Extension will play a role in information dissemination and technology transfer as it traditionally has, but perhaps more important is the role of educating the public sector and dealing with public perceptions relating to biotechnology. It is expected that the results of this study would assist Extension leaders in developing training programs for Extension staff, as well as developing informational materials for their use and by Extension clientele. Additionally, an indirect result from this study may be the identification of important topical areas in biotechnology as perceived by Agricultural Extension Agents that may provide direction to future research and developments by Extension and Land Grant University researchers and educators, and other agricultural researchers.

CHAPTER II. REVIEW OF LITERATURE

The primary purpose of this study was to identify the perceptions of Extension Agriculturists and Area Extension Agricultural Specialists in Iowa regarding agricultural biotechnologies. The specific objectives of this research study were: (1) To identify training and in-service education needs of Iowa Agricultural Extension professionals related to agricultural biotechnology; (2) To identify informational needs regarding various topical areas in the field of agricultural biotechnology; and (3) To identify perceptions of Iowa Agricultural Extension Professionals regarding bioethics, potential impact on U.S. agriculture, and Iowa State University Extension's educational role in the agricultural biotechnologies.

A search of the literature was made with the goal of becoming familiar with research and information related to this study. Agricultural biotechnology appears to be a relatively new field of study and area of interest. Most of the research and subsequent literature is from the last ten years. Land Grant Universities are targeting more studies of biotechnology, with several creating or developing biotechnology centers. A Biotechnology Council, formed in 1984 at Iowa State University, established an "Office of Biotechnology," which oversees the nearly $50 million received from the State of Iowa in recent years targeting biotechnology research and education (Current Research in Agricultural Biotechnology, 1990). Other land grant universities have established similar centers, exemplifying the commitment to researching biotechnology, especially those technologies applicable to agriculture

(Committee for a National Strategy for Biotechnology in Agriculture, 1987).

The Agricultural Research Service (ARS) of the United States Department of Agriculture (USDA) plans to expand biotechnology research (Kinney, 1985, p. 3). Kinney further indicated an ARS 1985 budget of $26 million for research in biotechnology, with some 200 scientists focusing on biotechnology projects at laboratories throughout the United States. The following comments made by Kinney (1985, p. 1) at a biotechnology symposium express the newly formed interest in biotechnology:

> To say this area of research is dynamic is an understatement. In fact, research in the biotechnologies is so rapid that articles written in scientific journals are often eclipsed by new developments before the articles are off the press. Biotechnology promises to yield an infinite number of improvements in just about every enterprise from health care to waste management. Most predictions point to agriculture as the industry that will reap the greatest benefits.

The commitment expressed by land grant universities and the Agricultural Research Service clearly illustrate the promise and importance biotechnology has towards agriculture.

The literature review proved useful in determining previous research and developments in biotechnology, identifying current studies, enumerating "visionary" ideas on areas to be researched, and finally, applying and merging the biotechnologies into agriculture.

The literature revealed contributory work in establishing the importance of biotechnology to agriculture, its promise and potential, as well as principles of science underlying the discipline of biotechnology. Furthermore, the study of literature reviewed the many new innovations and findings of biotechnology research. However, with the application of

biotechnology in somewhat of an infancy stage, very little work could be found on technology transfer relating to biotechnology, innovation-adoption of biotechnology, and information dissemination about biotechnology to farmers, agribusiness, and the general public. No previous work has been done in studying the perceptions of Extension Agents regarding agricultural biotechnologies. Thus, the review of the literature provided a rationale for this study.

This chapter has been divided into the following sections:

1. General overview of biotechnology
2. The role of biotechnology in agriculture
3. Specific agricultural biotechnologies and emerging technologies
4. Training and education
5. Technology transfer of agricultural biotechnology
6. Related studies
7. Summary

This chapter was designed to provide an overview of agricultural biotechnology and the role biotechnology may play in modern agriculture. This chapter targets three primary areas in agriculture, those being crop production, animal production, and food processing, with the intent to detail innovations from biotechnology that may have applicable implications to agriculture. The information in this chapter provides a foundation supporting biotechnology's future role in agriculture. This chapter also expounds on technology transfer and information dissemination regarding biotechnology, which is part of the innovation-adoption. Historically, the Cooperative Extension Service has played a role in this

process and will need to train staff regarding agricultural biotechnology and the innovations applicable to agricultural producers.

General Overview of Biotechnology

Biotechnology is not a scientific discipline in itself, but is made up of several disciplines. Biotechnology has been broadly defined as the utilization of biologically derived molecules, structures, cells, or organisms to carry out a specific process. According to Reilly (1989, p. 1):

> Despite its lack of a clear definition and its subtle revelation to consumers, in 20 years biotechnology will still appear revolutionary because its cumulative effects will have wrought major changes in agriculture and the food processing industry.

Reilly (1989, p. 1) further states that "biotechnology is not a product. It is a set of techniques for enhancing existing products and production practices."

Historically, biotechnology has been associated with use in medicine, and only recently has biotechnological processes moved into the agricultural arena. Many researchers and scientists believe that agricultural biotechnology has unlimited potential, and U.S. agriculture has much to gain from these emerging technologies. As with many new technologies, there are varied opinions on the potential impact of biotechnology to agriculture. Martin (1990, p. 182) expressed the viewpoint that:

> Biotechnology holds promise for contributing to additional agricultural productivity increases. But, it is important to remember that biotechnology tools complement and extend, rather than replace, traditional methods used to enhance agricultural productivity and to develop new production

> systems. While some see biotechnology as a revolutionary development, others see the development and application of biotechnology tools as an evolutionary process in a stream of agricultural technological developments.

The Role of Biotechnology in Agriculture

> The total system for food and fiber production is extremely diverse and multi-faceted, providing a broad range of potential applications of biotechnology. Biotechnology is not only enhancing the traditional enterprises in food and fiber production; it also is producing new high technology industries that are in themselves providing new jobs and producing new goods and services. Sometimes thinking of biotechnological applications is limited to production agriculture, where an exciting new array of scientific breakthroughs are being developed. Just as exciting, however, is the new application of biotechnology to food processing and manufacturing, to new methods for ecologically sound disposal of wastes, and to biochemical engineering where totally new products are being produced from agricultural residues using biotechnological tools. (Clarke, 1986, p. 39)

While Clarke suggested far-reaching applications of biotechnology, many researchers believe that the agriculture industry will benefit greatly from biotechnology.

> The power of biotechnology is no longer a fantasy. Biotechnology--the use of techniques based on living systems to develop commercial processes and products--now includes the techniques of recombinant DNA, gene transfer, embryo manipulation and transfer, plant regeneration, cell culture, monoclonal antibodies, and bioprocess engineering. Using these techniques, we have begun to transform ideas into practical applications. Yet we have barely scratched the surface of the potential benefits the tools of biotechnology will bring. Biotechnology offers new ideas and techniques to agriculture. (Committee on a National Strategy for Biotechnology in Agriculture, 1987, p. 3)

Biotechnology will ultimately provide processes and products in agriculture that will enable farmers to become more efficient producers of quality food and fiber products. Improving production efficiencies and profitability should help to keep U.S. farmers competitive in a world

marketplace. Biotechnology appears that it may impact all phases of agriculture, from conserving our resources, reducing dependency on pesticides and other inputs such as fertilizers, disease resistant plant and animals, new vaccines, growth hormones, to better quality end-products as well as new products derived from bioprocesses.

"Over the next 25 years, biotechnology will have few competitors for better and less expensive production processes. While it will not be the only source for productivity in the next 25 years, biotechnology will be an important component of whatever productivity growth we experience. Everyone gains from productivity growth. Failure to maintain productivity gains will erode agricultural exports, and a closed economy raises food prices and consumer losses" (Reilly, 1989, p. 9).

In summarizing the potential role of biotechnology in agriculture, many believe it has unlimited potential, while others perceive it as a threat. Milligan (1989) expressed the concern that in agriculture, biotechnology has often been viewed as a panacea for curing most problems, including the elimination of world hunger, or damned as a threat to the environment and the economic viability of the family farm. This statement perhaps reflects the viewpoint that biotechnology will have tremendous potential to impact U.S. agriculture, but will have to be sensitive to public perceptions.

Specific Agricultural Biotechnologies and Emerging Biotechnologies

While many new innovations in agricultural biotechnologies are on the horizon, several have already received extensive study, with a few starting to be utilized by major agribusiness in various bioprocesses, and

finally a small percentage in a marketable product. As indicated previously, agricultural biotechnology will most likely create only a few "new products," but will most likely have the most impact in engineering the plants, animals, or the microorganisms and insects associated with agriculture, utilizing biotechnology in various types of processes.

According to the Committee on a National Strategy for Biotechnology in Agriculture (1987), research should focus on six important areas in genetic engineering.

1. Gene identification - locating and identifying agriculturally important genes and creating chromosome maps.

2. Gene regulation - understanding the mechanisms of regulation and expression of these genes and refining the methods by which they may be genetically engineered.

3. Structure and function of gene products - understanding the structure and function of gene products in metabolism and the development of agriculturally important traits.

4. Cellular techniques - developing and refining techniques for cell culture, cell fusion, regeneration of plants, and other manipulations of plant and animal cells and embryos.

5. Development in organisms and communities - understanding the complex physiological and genetic interactions and associations that occur within an organism and between organisms.

6. Environmental considerations - understanding the behavior and effect of genetically engineered organisms in the environment.

While these six areas are pertaining to research in genetic engineering targeting application to agriculture, the potential to utilize the findings from this research could prove very valuable to other areas of research, both in agriculture and other disciplines. Genetic engineering is crucial to the advancement of biotechnology in agriculture.

In citing specific agricultural biotechnologies, the focus of this review will be in the areas of crop production, animal agriculture, and food processing and their bioprocesses.

Crop production

Crop production looks to benefit in the very near future from agricultural biotechnology, most notably in the development of herbicide resistant corn and soybean varieties, disease and pest resistant crop varieties, new varieties, biological control of certain pests, the utilization of diagnostic kits using biotechnology, and genetic engineering in general. Future applications may be the development of crop varieties that can produce their own nitrogen, as well as developing new uses from crop by-products. A brief overview of crop-related innovations stemming from biotechnology follows.

Herbicide resistant corn varieties are already being produced by major seed corn production companies, and are waiting on FDA approval for the 1992 crop year. These new biotechnically produced corn hybrids minimize herbicide carryover problems in corn associated with the imidazolinone family of herbicides. Major seed companies are also working on developing soybean plants resistant to glyphosate herbicides. Pesek (1988, p. 13) provided this viewpoint of herbicide-resistant crops:

> The development of herbicide-resistant crops offers opportunities to substitute safer herbicides for more dangerous herbicides. For example, efforts are being made to develop crops resistant to the herbicide glyphosate, a compound with very low mammalian toxicity. Like other broad-spectrum herbicides, glyphosate has limited use in crop production because it destroys crops as well as weeds and therefore must be used before crop germination or with special equipment. If the plants tolerate glyphosate, the herbicide

could then be used as a post-emergence treatment. In certain cases, this strategy could reduce weed control costs, improve weed control quality, and reduce human health hazards.

Integrated Pest Management (IPM) systems could utilize biological control techniques as a part of its strategy. Some of the techniques include the use of bacterial insecticides, release of male steriles, pest predators as parasites, use of insect pheromones, selection of pest resistant crop cultivars, and the immunization of host plants.

Biological control of insect pests is an area where biotechnology can impact crop production. A few biological control programs are already utilized in controlling certain crop pests, such as Bacillus thuringiensis for control of certain caterpillars, and a parasitic wasp to control alfalfa weevil. Disease can also be controlled or prevented using biological control methods. Even though biological controls have not been developed or used extensively, their potential is great. Cost and the need for further research seem to be limiting factors at the present time.

Immunoassays are diagnostic tests that can detect the presence and/or concentration of a compound. Immunoassays are a classic example of the utilization of biotechnology as they are traditional methods for doing the same tests, but through the use of biotechnology, the immunoassays are faster, less expensive, highly reliable, and require less preparation time.

While immunoassays have been utilized in the medical field for some time (i.e., home pregnancy test for women), they are relatively new to agriculture. Anticipated uses of immunoassays in agriculture include

testing for pesticide residues, diagnosing plant and animal diseases, and the detection of mycotoxins in grain.

Plant breeding has been practiced for many years, and with the onset of biotechnology, tremendous potential exists as scientists are finding ways to alter the genetic makeup of plants.

The Committee on a National Strategy for Biotechnology in Agriculture (1987, p. 23) suggested that in its simplest form, genetic engineering involves inserting, changing, or deleting genetic information within a host organism to give it new characteristics. The committee further put genetic engineering into perspective by stating:

> Perhaps the most direct way to use biotechnology to improve crop agriculture is to genetically engineer crop plants--that is, to alter their basic genetic structure--so they have new characteristics that improve the efficiency of crop production. The traditional goal of crop production remains unchanged: to produce more and better crops at lower costs. However, the tools of biotechnology can speed up the process by helping researchers screen generations of plants for a specific trait or work more quickly or precisely to transfer a trait. These tools give breeders and genetic engineers access to a wider universe of traits from which to select. (p. 24)

A study by Benbow et al. (1990, p. 31) helps illustrate the type of research currently being conducted, which is developing a recently discovered method for introducing new or modified genes into soybean plants more rapidly and efficiently than with traditional plant breeding techniques. These scientists stated the following commercial applications of their research:

(1) Development of a plant gene transfer system for introduction of any desired gene into soybeans.

(2) Introduction into soybean genes that code for such things as resistance to salt, drought, heat, disease-causing fungi, and insects for greater efficiency in crop production.

(3) Production of nutritionally improved soybean oil and protein from genetically engineered soybeans to increase consumer demand for these products.

(4) Introduction of new genes not previously found in soybean plants to increase the commercial value of this crop.

This list of commercial applications by these scientists clearly indicate the potential for genetic engineering in crop production.

Animal agriculture

The basis of animal breeding over the centuries has been the selection and breeding of superior animals. Biotechnology will enhance this process, primarily by speeding up genetic improvements, as well as provide growth hormones, develop diagnostic tests for pregnancy detection and disease control. Artificial insemination has been a technology used in the dairy industry, and to a lesser degree in beef cattle breeding. Embryo transfer is another technology used in making genetic improvements by multiplying offspring from superior individuals. These technologies and biotechnology will continue to speed up genetic improvement in animal agriculture, with faster and more efficient methods in improving and manipulating important traits in livestock.

Mapping genes in beef animals is the focus of a $2 million research project at the U.S. Meat Animal Research Center (MARC) in Clay Center, Nebraska. Biotechnology allows scientists to use DNA probes to identify

gene markers, which will be used to mark various production traits that are of economic importance to beef producers. According to an article by Gerriett (November 1991, p. 18) in Agricultural Research, Roger Gerrits, National Research Service program leader for animal production, stated that "Gene mapping and evaluation will accelerate the rate of genetic progress and will be essential to improve the quality and safety of food for human diets, as well as competitiveness of U.S. agriculture." Gerrits further stated that "research with the bovine genome will accelerate our ability to improve reproduction, meat quality, disease resistance, and the metabolism of muscle and fat." Gene mapping will ultimately provide new tools to select and improve upon economically important traits in livestock, especially those that increase efficiency and productivity.

The use of gene transfer technology in animals is somewhat behind that used in crops, according to the Committee on a National Strategy for Biotechnology in Agriculture (1987). Factors explaining some differences in utilizing gene transfer in animals mentioned by this committee infer that:

> Molecular gene transfer into animal cells predates similar experimentation with plants. Unlike plants, however, animals cannot be regenerated asexually. Thus, the only way to introduce a foreign gene into all the cells of an animal, including the cells that allow it to pass the trait to its offspring, is to insert the foreign DNA into germ cells--the sperm or the egg--or into the product of their union--the zygote. (Committee on a National Strategy for Biotechnology in Agriculture, 1987, p. 34)

This statement reiterates the importance of gene mapping as fundamental to using genetic engineering in animals. Knowing the genetic background will enable scientists to use the other technologies such as

gene transfer and cloning, utilizing the animal germ cells. Embryos have been the target of several innovations in the livestock industry over the past decade, as artificial insemination and embryo transfer have been utilized by livestock producers. Recently, gender selection has been possible, through the use of processes involving biotechnology. "Transgenic animals are in the future, and their implications may not be fully realized until further research and experimentation is completed" (Committee on a National Study for Biotechnology in Agriculture, 1987).

Of all the new innovations resulting from advancements in biotechnology, the growth hormones have been the most controversial. Recombinant DNA technology has allowed scientists methodology to produce growth hormones for injection into farm animals.

The growth hormones Bovine somatotropin (BST) and Porcine somatotropin (PST) have been researched extensively, and are awaiting Food and Drug Administration (FDA) approval and licensure for use in farm animals. "The growth hormones are natural substances produced in an animal's pituitary gland, and are important for growth, development, and other body functions" (Hartwig, 1990, p. 1). Hartwig further stated that "research results indicate improved feed efficiency and increased milk production in dairy animals utilizing BST."

PST has similar responses in pork production, influencing feed efficiency and leanness. Although not as controversial as BST, PST is still awaiting FDA approval. Perhaps even more important will be producer and consumer acceptance of PST. Daily injection requirements will inhibit its adoption by farmers, and consumer confidence in the pork quality will

indirectly influence adoption rates of PST, according to Busby and Stender (1990).

The growth hormones could prove to be extremely important to biotechnology in general, as the issue is not the benefits they could provide livestock producers, but in the way they are perceived by the general public. Hartwig (1990, p. 7) supports this statement when he states that the:

> approval and use of BST is highly controversial and will have a significant effect on research and development investment in biotechnology in agriculture by commercial firms. Universities will face the difficulty of presenting scientific information in a manner that both is, and gives the appearance of being, unbiased. An era of direct challenge to technology itself is relatively new to most professional agriculturists. Patience, tolerance, and understanding will be required by educators, extension workers, and other professionals in agriculture who work with groups that either support or oppose implementation of technology such as BST.

Monoclonal antibodies, pregnancy tests, disease diagnostic tests, and vaccines are additional areas where biotechnology may impact animal agriculture. Monoclonal antibodies are produced by fusing a cancerous cell with a cell that produces an antibody, creating a hybridoma, which produces large quantities of identical or monoclonal antibodies in a pure, highly concentrated form, as described by Snyder (1986). These can be used in many ways, but are currently used in producing vaccines, disease diagnostic tests, and pregnancy tests.

Food processing

The food processing industry had been practicing biotechnology for many years before biotechnology was recognized as a discipline. The cheese-making and brewing factions are examples of the food processing

industry that have utilized biotechnology, using enzymes to make cheese and fermentation processes for brewing. A summary of food biotechnology was compiled by the Institute of Food Technologists' Expert Panel on Food Safety and Nutrition (1988, p. 1), and offered this viewpoint:

> The beauty of biotechnology lies in its specificity. The biotechnologist can target only one or two protein molecules for change in an organism containing thousands of proteins. This seemingly minor alteration can have profound effects. The amount of an important flavor, color, or enzyme may be increased manyfold.

The report further stated that with few exceptions, most short-term results of biotechnology applied to food production will be invisible to the consumer's eye; however, indirect effects on existing products, such as cost savings and product improvements, will be far-reaching.

Genetic engineering, enzyme production and improvements, fermentation, and immunoassays are all aspects of biotechnology that are of particular interest to the food processing industry.

According to the Scientific Status Summary of the Institute of Food Technologists' Expert Panel on Food Safety and Nutrition (The Institute of Food Technologists, 1988), there are several proposed uses for genetic engineering in helping to solve food production problems, as indicated in the following table.

In addition to the genetic engineering solutions described in this table, there is tremendous potential in the production and improvement of enzymes used in the food processing industry.

The food processing industry is currently the largest consumer of industrial enzymes, making up about 40 percent of a $400 million market, according to Harlander and Garner (1986). Recombinant DNA methods will

Table 1. Some proposed genetic engineering solutions to problems in food production

Problem	Solution
Availability of cal rennin for cheesemaking is limited	Induce microorganisms to produce calf rennin by interspecies gene transfer of the calf gene to yeasts or fungi
Environmental problems are caused by disposal of large volumes of lactose-containing whey	Transfer the lactase gene from Escherichia coli into yeast, which is able to use sugars for fermentation
Many enzymes lack stability for use in food processing	Engineer minor structural changes in enzyme molecule that lead to new and stronger internal bonding patterns by pinpoint alteration of the structural gene
Microorganisms and plant cells produce desirable proteins and enzymes, but at levels too low for commercial utility	Amplify the number of genes coding for those proteins to increase protein or enzyme output
Frost damage limits the growth season of many fruits and vegetables	Genetically modify Pseudomonas syringae to delete one of its proteins that promotes ice nucleation; spray organism on plant to compete with natural flora
Herbicides are toxic to desirable crops as well as to weeds	Transfer gene for an enzyme that catabolizes herbicide into plant or genetically modify herbicide target site
Appearance of softening enzymes in fruits and vegetables such as pectinases and cellulases leads to senescence and short shelf life	Identify genes for these enzymes to understand how their appearance is regulated. Use this knowledge to design improved cultivars and storage and handling techniques
Frozen vegetables sometimes become rancid due to the action of the enzyme lipoxygenase	Pinpoint the lipoxygenase gene to understand its regulation, and develop methods to limit its expression

Table 1. (Continued)

Problem	Solution
Important grains and legumes are deficient in essential amino acids; e.g., soybean is low in sulfur-containing amino acids, and corn is low in lysine	Amplify genes coding for proteins containing low levels of these amino acids for increased protein production; evaluate nutritional value and functionality of expressed proteins

influence enzymes which are currently used in food processing to help control texture or appearance, enhance nutritive value, and generate desirable flavors and aromas.

Fermentation is a vital part of food processing, especially in the production of alcoholic beverages, bread, and cheese. Lund (1986) describes fermentation as a reaction or series of reactions in which a biocatalyst, usually a microbial cell or isolated enzyme, is used to convert a substrate or chemical constituent into a desirable product. He further suggests that biotechnology may make these complex systems more efficient by utilizing bioreactors.

Quality control is of critical importance in the food industry, and immunoassays will play an increasingly important role in this area. Harlander and Garner (1986) indicate that biotechnology has been used to develop sensitive, reliable, and rapid detection methods to expedite the ensuring of a safe food supply. A classic example would be the use of a detection kit for Salmonella, utilizing monoclonal antibody technology.

Bioassays will continue to be developed to serve as diagnostic tools for the food processing industry.

Training and Education

The arena of biotechnology has attracted attention from private industry and universities, with increased emphasis being placed on research and education. Of course, education is of vital importance as research is developed and conducted, making training important in the field of biotechnology. Since there is no particular science called biotechnology, a varied background in several science disciplines is of importance to persons pursuing careers in biotechnology. Land grant universities and certain companies in the private sector are developing training programs for persons interested in biotechnology, and providing support in the study of biosciences. According to the Committee on a National Strategy for Biotechnology in Agriculture (1987), biotechnology appears to be in an alliance based on emerging public sector knowledge of basic science and private sector technology development.

The Cooperative Extension Service could play a major role in technology transfer regarding biotechnology, thus the importance for establishing training programs and providing informational materials to Agricultural Extension Agents involved with the innovation-adoption process concerning agricultural biotechnology. Additionally, the Cooperative Extensive Service will play a role in applied research in biotechnology, as new innovations in biotechnology are researched as to their applicability and practicality. The Agricultural Extension Agent can utilize research data and technical information to inform others

regarding biotechnology, thus the need for training and informational materials.

Martin (1987, p. 7) stated that "a biotechnologically derived product intended for commercial use goes through four stages: basic research, development, manufacture, and sales." Scientists, managers, market specialists, sales personnel, and regulatory specialists will all be essential in making biotechnologically derived products available to the consumer. Education and training will not only be important in preparing persons that will work directly with biotechnology, but also to the adopter of new technologies, as well as the eventual consumer and the general public. The survey instrument used in this study focused primarily on educational and informational needs of Agricultural Extension Agents in Iowa regarding biotechnology.

Technology Transfer of Agricultural Biotechnology

The Cooperative Extension Service has traditionally played a major role in the transfer of new agricultural technologies and innovations to farm producers. An essential element of the adoption process is information, whether it be from the Cooperative Extension Service, manufacturers, agribusiness, or neighbors. Educational efforts aimed at providing accurate information is crucial to informed decision making and the adoption of new technologies. Kliebenstein (1989) stated that while biotechnology represents an arena where some dramatic new discoveries are likely, the tools farm managers use to evaluate whether to use a particular new technology will likely be tools now available--such as budgeting, cash-flow analysis, and systems analysis. The bottom line is

to determine the greatest economic return. Extension and other educational organizations have historically been providing educational assistance to farm operators, with the goal of improving farm profitability and competitiveness.

Kliebenstein (1989) further suggested that farm managers will need to identify probable impacts of the new technology on their farm operations. To do so will require knowledge about the technology, its use, and expected production impacts. This statement reiterates the importance of education in the innovation-adoption process. Extension, as well as other sources, will be relied upon as a source for research-based information regarding agricultural biotechnology and new innovations produced by biotechnology. This study is utilizing a survey to help identify informational and training needs of Extension Agricultural Agents in Iowa regarding agricultural biotechnology.

The Committee on a National Strategy for Biotechnology in Agriculture (1987, p. 14) suggests that Extension should have a role in the transfer of biotechnology research:

> The Cooperative Extension Service (CES) should focus some of its efforts on the transfer of biotechnology research that will prove adaptable and profitable to the agricultural community. It should train many of its specialists in biotechnology and increase its interaction with the private sector to keep abreast of new biotechnology valuable to the agricultural community. Furthermore, CES should work to anticipate and alleviate social and economic impacts that result from the application of new biotechnologies. CES should play a key role in educating the public about biotechnology.

This recommendation not only indicates the need to educate the user of new innovations, but educate the general public as well. This may be

considered by many a new role for CES, as historically direct users of innovations were the targeted audiences.

Martin (1990, p. 187) summed up this point by stating:

> Extension specialists must learn to treat biotechnology as a public policy issue much like we have treated agricultural policy. In the past, extension agents basically helped farmers adopt a new technology without much public discussion of its broader social and economic impacts. Today a much broader clientele wants to influence the development and adoption of agricultural biotechnology.

Biotechnology may be unlike other new innovations previously adopted by the agricultural sector in that it may be questioned, and perhaps attacked by groups, organizations, or factions, that have differing agendas. Biotechnology may prove to be controversial, as the public sector is used to sway policy and regulation. An example is the product BST, which was discussed in a previous section. BST has been found to increase milk production in animals, but groups both inside and outside of agriculture are trying to prevent its approval for use by dairy farmers. Martin (1990, p. 189) summarized the important role in educating the public when he stated:

> Moreover, we in the Land-Grant system must design and implement appropriate public policy extension programs to help the public better understand the technical and socio-economic ramifications of alternative choices before us as a society. If we fail in this task, controversy will grow and potential benefits to society will be lost.

Related Studies

The relative newness of increased emphasis in biotechnology is evident with most of the literature published in the 1980s, and most of it dealing with exploratory research. There has not been a lot of work done

on the educational and application aspect of biotechnology, as many innovations are still being developed, and only a few being marketed at the present time. This study intends to focus on the technology transfer and educational aspect of biotechnology.

A special committee was appointed in Iowa in 1987 to investigate the potential impact of biotechnology on the study of agriculture at various levels of education but particularly at the secondary school level (Martin, 1987). This technical committee specifically addressed how biosciences can be incorporated into high school vocational agriculture curricula and identified and developed a curriculum outline for biotechnology subject matter.

A study by Vold (1987) identified perceptions of vocational agriculture instructors in Iowa regarding biosciences in the study of agriculture, with teachers agreeing that infusing bioscience competencies was moderately to highly important. Vold's study also identified plant science, genetics, animal science and soil science as important topics for infusing biotechnology into agriculture curricula as perceived by vocational agriculture instructors. Both the special technical committee and the study of perceptions of vocational agriculture instructors towards biotechnology indicated that high school students will likely be exposed to biotechnology, primarily by infusing the biosciences into the agriculture curriculum in many schools in Iowa.

In a poll of farmers in Iowa conducted by Lasley (1991, p. 7), "More efficient livestock production and crops that require fewer chemicals are desirable results that might come from the expanding field of

biotechnology research." The survey studied farmers as to their opinions regarding likely results of biotechnology research and its potential impact on U.S. agriculture. The study further indicated that farmers surveyed felt that biotechnology research should be emphasized, with 61 percent indicating some or much more emphasis on biotechnology - new species research, 42 percent on biotechnology products such as growth stimulants, and 77 percent on biotechnology - new plant varieties research, as reported by Lasley.

As further research is conducted in the field of biotechnology, information and systems for technology transfer of biotechnology will become increasingly important. Related studies suggest that biotechnology will most likely be infused into high school agriculture curricula, and there is a need for additional education as biotechnology innovations are developed.

Summary

The review of the literature presented a wide array of opinions and perceived potential of biotechnology in agriculture. Many agricultural leaders agree that biotechnology has tremendous potential to impact agriculture, as demonstrated by the establishment of biotechnology centers, special committees, and research emphasis by the Agricultural Research Service, Land Grant Universities, and private industry. Biotechnology still seems to be in its infancy, as most of the work is of recent nature. Biotechnology is attracting media coverage, as research has stimulated interest resulting from new developments and findings.

The information gathered in the literature review provided the theoretical framework for conducting a study of perceptions of Agricultural Extension Agents regarding biotechnology. The review of the literature also established a rationale for the need for education in regard to biotechnology, not only for the eventual user, but the general public as well. The literature search revealed little work directed at identifying perceptions of Agriculture Extension Agents regarding biotechnology. If Extension is to play a role in the transfer of technological information to farmers, agribusiness personnel, and the general public in regard to biotechnology, it appears to be important that perceptions of Agricultural Extension Agents be identified regarding biotechnology, as well as their informational and training needs.

CHAPTER III. METHODS AND PROCEDURES

The research project was selected because of the increasing attention biotechnology is receiving from researches and educators in agriculture. Extension has historically been involved with major technological advancements in agriculture, and biotechnology possesses the potential to impact agriculture. Identifying perceptions of Extension Agricultural Agents towards biotechnology should contribute to the educational aspect of biotechnology and adoption of innovations resulting from developments in biotechnology.

The primary purpose of this study was to identify the perceptions of Agricultural Extension Agents in Iowa regarding training and informational needs relating to agricultural biotechnology, as well as perceptions regarding bioethics, impact on agriculture, and Extension's role in education concerning biotechnology. The following specific objectives were developed in order to provide a framework for conducting this study:

1. To identify the level of importance of agricultural biotechnology as perceived by Agricultural Extension Agents in Iowa.
2. To determine the extent of training felt needed by Agricultural Extension Agents in Iowa regarding various topical areas in biotechnology.
3. To determine the degree of importance relating to informational material needed by Agricultural Extension Agents in Iowa regarding various topical areas in biotechnology.

4. To identify perceptions held by Agricultural Extension Agents in Iowa in regard to bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education in the agricultural and public sectors.
5. To compare perceived differences existing in Agricultural Extension Agents in Iowa regarding agricultural biotechnology according to various demographic factors.

This chapter is divided into seven sections as follows: research design, population and sample, instrumentation, methods of data collection, statistical analysis of the data, limitations of the study, assumptions of the study, and summary.

Research Design

The research approach used in this study was descriptive, utilizing the survey method. A self-administered questionnaire was developed for data collection due to the advantages of time and expense (Dillman, 1978). It was determined that this survey instrument should be sent to all Extension field staff in Iowa with agriculture responsibilities.

Population and Sample

Agriculture Extension Agents were the target population chosen for the study, and the Extension Agricultural Agents in the Iowa Cooperative Extension Service served as the accessible population for this study.

It was determined that agents serving as Extension Area Specialists with agriculture responsibilities and county Extension Agriculturists in Iowa would be surveyed. The program leader for Agriculture and Natural

Resources for Iowa State University Extension was contacted, who provided access to a mailing list of the population to be surveyed. Approval for the study of this group was received from the program leader.

The mailing list consisted of 31 Extension Area Specialists with agriculture responsibilities and 89 county Extension Agriculturists. All 120 agents were mailed the survey instrument due to the relatively small size of the accessible population.

Instrument Development

The instrument used in this study was primarily designed to identify attitudes and perceptions, and a survey questionnaire was developed to collect data for this study (see Appendix A). This instrument was developed considering the following factors: (1) information gathered in the literature review; (2) other instruments used to collect similar information; (3) input from the researcher's major professor and Iowa State University Extension staff; and (4) personal knowledge of the researcher.

After the first draft of the questionnaire, revisions concerning content and structure were made based on input from the researcher's major professor and other Extension professionals. Major revisions included the reduction of topical areas in biotechnology from 35 items to 20-25 items, and reducing the number of questions asked about perceptions from 39 to 20-25. Clarification of questions and some wording changes were made to improve questions and descriptions. The instrument included the following parts:

1. Section 1 asked the respondents to indicate their level of agreement on a five-point scale regarding the need for training in various topical areas of biotechnology in the left column, and indicate their level of agreement to the need for informational materials in the right column.
2. Section 2 asked the respondents to indicate their level of agreement with statements regarding agricultural biotechnology, including statements concerning bioethics, potential impact on agriculture, and Extension's role in biotechnology education.
3. Section 3 requested demographic information specific to each respondent. Space for comments regarding previous training in biotechnology and Extension's role in providing leadership in agricultural biotechnology was also provided.

Likert-type scales were utilized in sections 1 and 2 as follows:

1 = (S)trongly (D)isagree

2 = (D)isagree

3 = (N)eutral

4 = (A)gree

5 = (S)trongly (A)gree

The questionnaire was submitted to and approved by the Human Subjects Committee, Iowa State University (Appendix B).

Collection of Data

On March 1, 1992, questionnaires were mailed to 31 Iowa State University Extension Area Specialists with agriculture responsibility and

to 89 county Extension Agriculturists. A cover letter was attached to the questionnaire explaining the purpose and scope of study, and also included was a self-addressed stamped envelope. The individuals contacted were asked to complete the questionnaire and return it to the investigator by March 16, 1992. A code number (001-120) was assigned to each individual and the number was marked on the top right corner of the questionnaire to identify nonrespondents and to conduct follow-up efforts. Upon receipt of the questionnaires, the investigator clipped off the number and marked the participant list to indicate return of the survey.

By March 9, 1992, 75 questionnaires had been received. It was decided to utilize "Exnet," Iowa State University's communication system to outlying centers, to send a short follow-up note requesting nonrespondents to complete and mail the questionnaire (Appendix C).

By March 16, 1992, a total of one hundred four questionnaires had been returned, for a final return rate of 87 percent. Ninety-five of these survey forms were in a usable form for processing, as nine questionnaires were incomplete.

With the return rate being 87 percent, the researcher elected not to follow up with nonrespondents, as only 16 Agricultural Extension Agents failed to return the survey. However, the researcher did elect to use the nine questionnaires as a check to see if any significant statistical differences existed between the group data and data from incomplete questionnaires. Every eighth item was identified from the questionnaire, and thus nine items were selected. The follow-up with the data collected from the unused questionnaires yielded no significant differences between

the responses of those participating in the survey and the responses on the unused questionnaires.

Analysis of Data

A survey analysis program from Iowa State University Extension Software was used to compute frequency counts, means, and standard deviations. Data were statistically analyzed using Iowa State University's Statistical Package for the Social Sciences (SPSSx). A Cronbach alpha was computed for the items on the survey in order to evaluate the reliability of the instrument. Means, standard deviations, frequencies, t-tests, and analysis of the variance were used in the study.

Assumptions

The following assumptions were made regarding the study:

1. Accurate, objective responses were provided in this survey by Extension Agricultural Agents in Iowa.
2. Respondents accurately and objectively evaluated the topical areas in biotechnology as to their own training and informational needs.

Other assumptions associated with this study deal with Extension clientele. First of all, it was assumed that biotechnology related innovations are available to farm operators, an example being growth enhancers such as PST being released for use in swine production. Secondly, the assumption was made that farm operators are interested in learning more about new technologies and would consider their adoption. Previous adult farmer education research associated with adoption-

diffusion identifies awareness and information gathering as a part of the adoption process, and it is assumed that farm operators will seek information and gain knowledge prior to adoption of a new technology. It is also assumed that the general public is interested in biotechnology.

Limitations of the Study

Agricultural Extension Agents in Iowa are being utilized in the study; thus, findings may have limited application to Agricultural Extension Agents in general, and to other populations.

The topical areas of biotechnology used in the instrument reflect an overview of important topics as perceived by the researcher, and were not intended as a complete listing of topics regarding agricultural biotechnology.

The rated responses to questions on training and informational needs are based on perception and cannot necessarily be used to signify the importance of these topics, although it can be implied.

Summary

Identifying perceptions of Agricultural Extension Agents regarding training and informational needs in biotechnology, and their perceptions regarding bioethics, biotechnology's potential impact on agriculture, and Extension's role in education concerning biotechnology was the primary purpose of this study. The descriptive survey method was the research design used in the study. The accessible population consisted of 31 Area Extension Specialists with agriculture responsibilities and 89 county Extension Agriculturists in Iowa. A questionnaire was sent to the 12

individuals indicated, and 104 were returned for an 87 percent return rate, with 95 in a usable form for processing. Mean scores and standard deviations were computed. T-tests and analysis of variance were used to draw comparisons between selected demographic factors and perceptions of Agricultural Extension Agents regarding biotechnology.

CHAPTER IV. PRESENTATION OF THE FINDINGS

The primary purpose of this study was to identify the perceptions of Agricultural Extension Agents in Iowa regarding training and informational needs relating to agricultural biotechnology, as well as perceptions towards bioethics, biotechnology's potential impact on agriculture, and Extension's role in education concerning biotechnology. The study identified 23 various topics pertaining to agricultural biotechnology to be ranked according to training and informational needs by the Agricultural Extension Agents in Iowa. Additionally, 20 questions dealing with statements pertaining to bioethics, potential impact on agriculture, and Extension's educational role were asked. Finally, respondents were asked to provide demographic data including gender, age, number of years employed by Extension, educational level, Extension Area located, if county or area staff, attendance at educational offerings, and awareness of the biotechnology office on the ISU campus. The demographic section also asked for comments on Extension's leadership role in agricultural biotechnology.

The findings of this study were discussed and presented according to the objectives outlined in Chapter I with the following subheadings:

1. Reliability
2. Demographic Data
3. Perceptions Regarding the Need for Training
4. Perceptions Regarding the Need for Informational Materials
5. Perceptions Regarding Biotechnology Statements
6. Comments by Respondents

Reliability Tests

Cronbach's Alpha procedure was used to examine the level of internal consistency and stability of the items related to agricultural biotechnology in the survey instrument. Table 2 displays the results of the reliability tests. The overall reliability of the instrument was determined to be .9022. The alpha coefficient was computed for the 23 topical items for both training needs and informational needs. The coefficients for these areas were .8998 and .8987, respectively. A reliability test was also computed for items on the survey dealing with perceptions of Agricultural Extension Agents regarding biotechnology. The coefficient for this area was .9044. These coefficient values were considered sufficiently high to proceed with statistical analysis and data interpretation.

Demographic Data

This section describes the demographic data of the Iowa Agricultural Extension Agents who participated in the study. One hundred twenty

Table 2. Results of reliability tests for the instrument sections

Sections	Number of items in section	Cronbach's alpha coefficient
Need for training	23	.8998
Need for informational materials	23	.8987
Perceptions regarding biotechnology	20	.9044
Total	66	.9022

questionnaires were mailed to the selected participants, and 95 usable questionnaires were received.

Figure 1 illustrates the distribution as to gender of the Iowa Agricultural Extension Agents surveyed. Agents with agricultural responsibilities are predominantly male, making up 94.7% of the respondents. The breakdown in numbers according to gender were 90 male and 5 female.

The distribution of respondents by age is presented in Figure 2. The age of Agricultural Extension Agents in Iowa ranged from 28 to 63, with the overall average age of 45.1. Overall, seventeen (17.9%) respondents indicated an age less than 35 years of age; twenty-nine (30.5%) reported an age between 36 and 45 years; thirty-five (36.8%) respondents reported an age between 46 and 55 years; and fourteen (14.8%) respondents indicated an age over 56 years. The respondents' age distribution revealed that over two-thirds (67.3%) of the Iowa Agricultural Extension Agents reported ages between 36 and 55 years. Thirty-five percent of the respondents indicated their age being between 46 and 55 years. The age group 56 to 65 years was the smallest group; almost 15 percent reported an age in this range.

The distribution of the respondents according to the number of years of experience reported as an Agricultural Extension Agent is presented in Figure 3. Forty-seven respondents, almost half (49.5%), indicated they had less than 10 years of experience as an Agricultural Extension Agent. The years of experience of other agents responding were twenty (21.1%) reporting between 11 to 20 years; nineteen (20.0%) with 21 to 30 years;

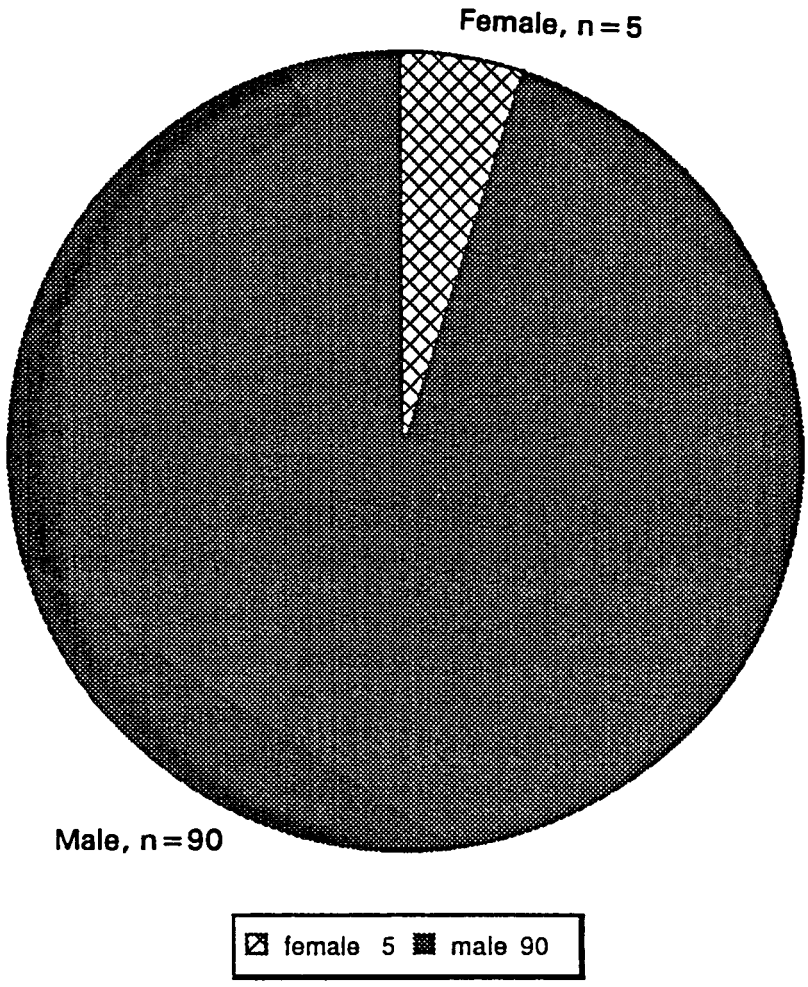

Figure 1. Gender of Iowa Agricultural Extension Agents (n=95)

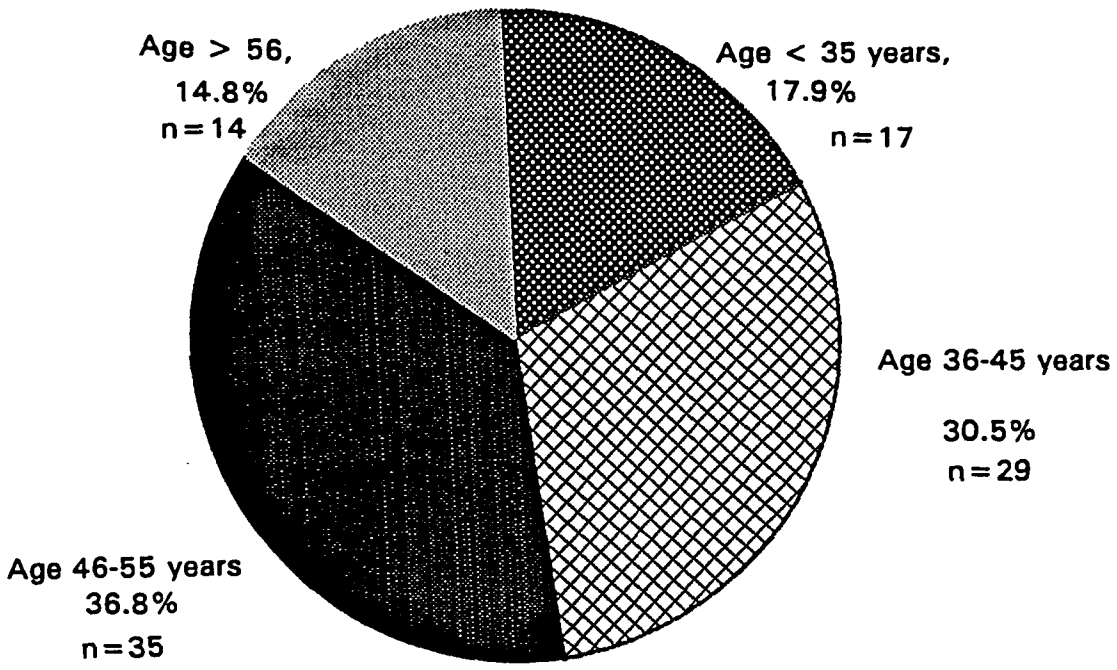

Figure 2. Age in years of Iowa Agricultural Extension Agents (n=95)

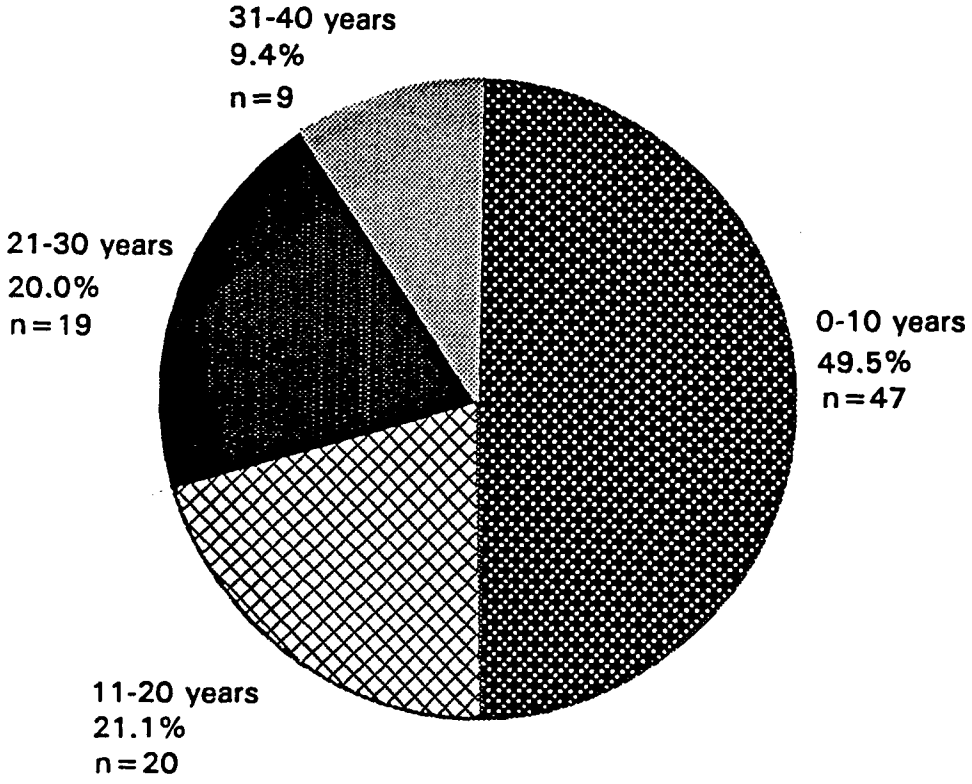

Figure 3. Experience in years of Iowa Agricultural Extension Agents (n=95)

and nine (9.4%) with over 31 years of experience. Overall, the average for years of experience among Agricultural Extension Agents participating in the study was 14.7 years.

The distribution of the respondents according to educational level of Agricultural Extension Agents in Iowa is displayed in Figure 4. The data indicated that the largest group were the 71 respondents who had achieved a master's degree (M.S.), representing 74.7% of the respondents. A bachelor's degree (B.S.) was held by seventeen (17.9%) of the agents, while seven (7.4%) indicated having a doctoral degree (Ph.D.).

The distribution of respondents by Extension administrative area is presented in Figure 5. The Extension administrative areas of the Agricultural Extension Agents participating in the study were those areas as designated before the 1992 Iowa State University Extension reorganization. The seven Extension administrative areas in Iowa were referred to as Southeast (SE), Southwest (SW), Northeast (NE), Northwest (NW), North Central (NC), Central (C), and East Central (EC). These areas were comprised of 9 to 18 counties, with each area having both county and area Extension staff with agriculture responsibilities. Of the Iowa Agricultural Extension Agents responding, twelve (12.6%) of the respondents were from the Southeast Area; sixteen (16.8%) of the respondents were from the Southwest Area; sixteen (16.8%) indicated they were from the Northeast Area; eleven (11.6%) reported they were in the Northwest Area; fourteen (14.7%) of the respondents were from the North Central Area; eleven (11.6%) indicated they were from the Central Area;

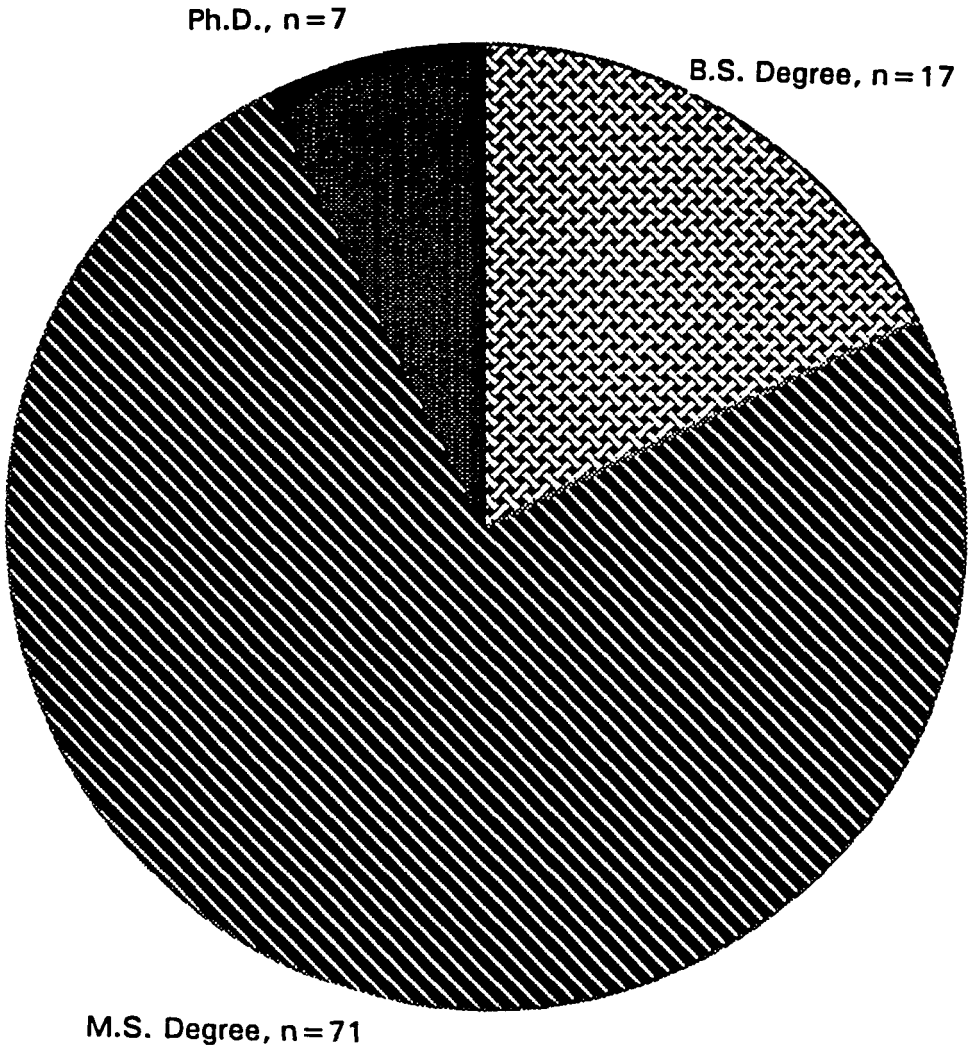

Figure 4. Educational level of Iowa Agricultural Extension Agents (n=95)

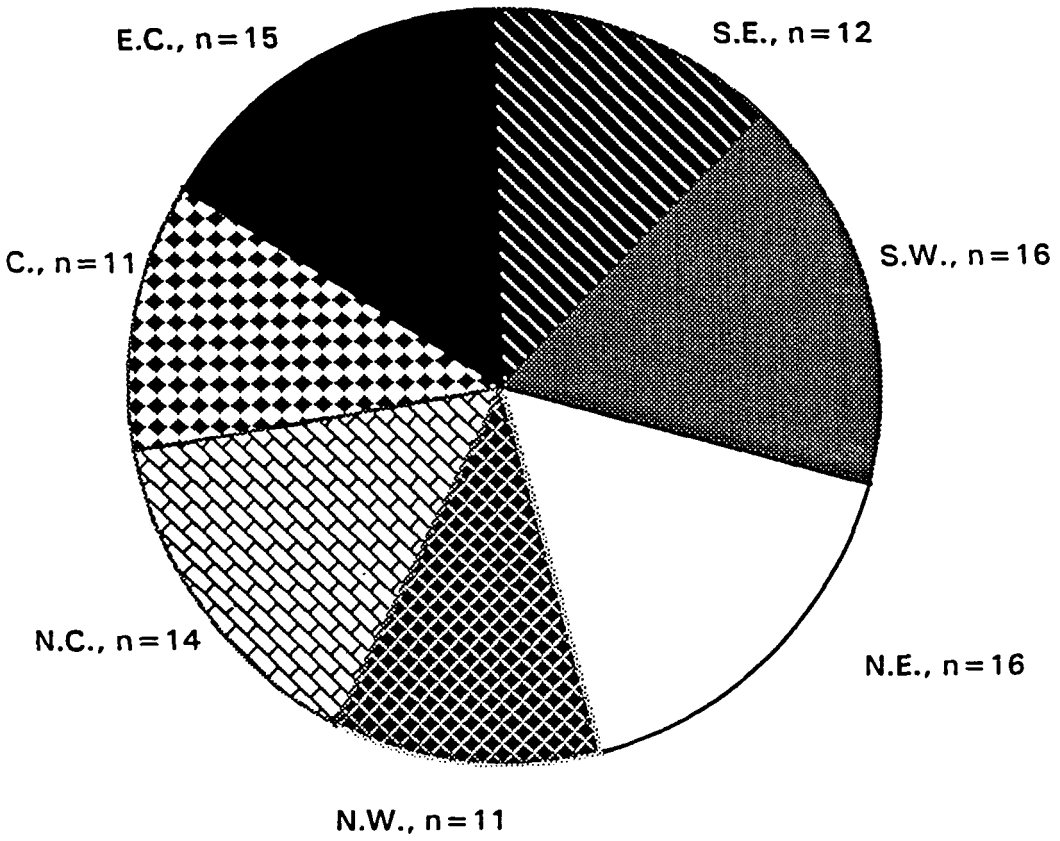

Figure 5. Extension administrative area of Iowa Agricultural Extension Agents (n=95)

and fifteen (15.8%) of the respondents reported being from the East Central Area.

The distribution of the respondents by their position with Extension is presented in Figure 6. This study targeted Iowa State University Extension field staff with agricultural responsibilities, which included county Extension Agriculturists and Extension Area Specialists. Of the Iowa State University Extension field staff with agricultural responsibilities, seventy-three (76.8%) indicated they were county Extension Agriculturists, and twenty-three (23.2%) reported being Extension Area Specialists.

Iowa Agricultural Extension Agents participating in the study were asked if they had attended any workshops, conferences, or course work pertaining to biotechnology, and Figure 7 presents the results of this question. Fifty (52.6%) respondents indicated that they had attended some type of educational activity pertaining to biotechnology; forty-five (47.4%) of the respondents reported they had not attended any type of educational training pertaining to biotechnology.

Respondents were asked if they were aware of the "Office of Biotechnology" located on the Iowa State University (ISU) campus. The majority of the Iowa Agricultural Extension Agents surveyed indicated that they were aware of this office on the ISU campus, with eighty-three (87.4%) respondents reporting they were aware of this office, while twelve (12.6%) respondents indicated they were not aware.

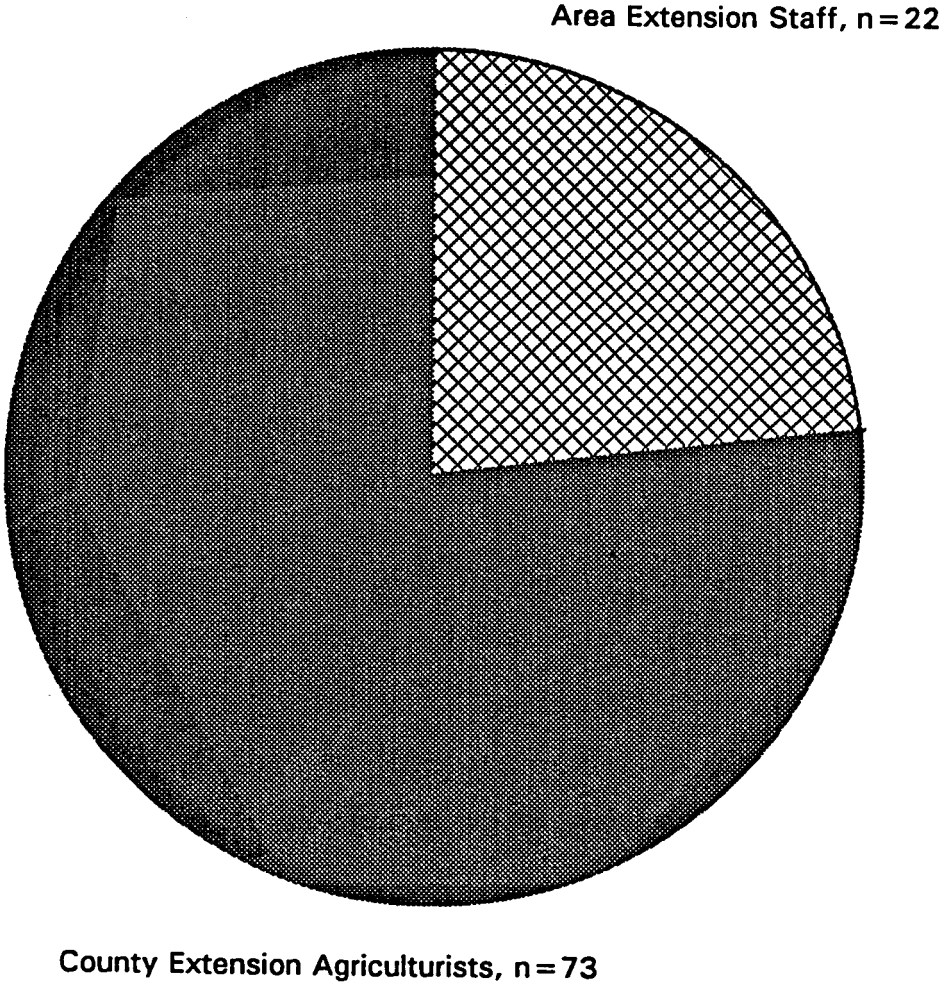

Figure 6. Iowa Agricultural Extension Agent designation as area or county Extension staff (n=95)

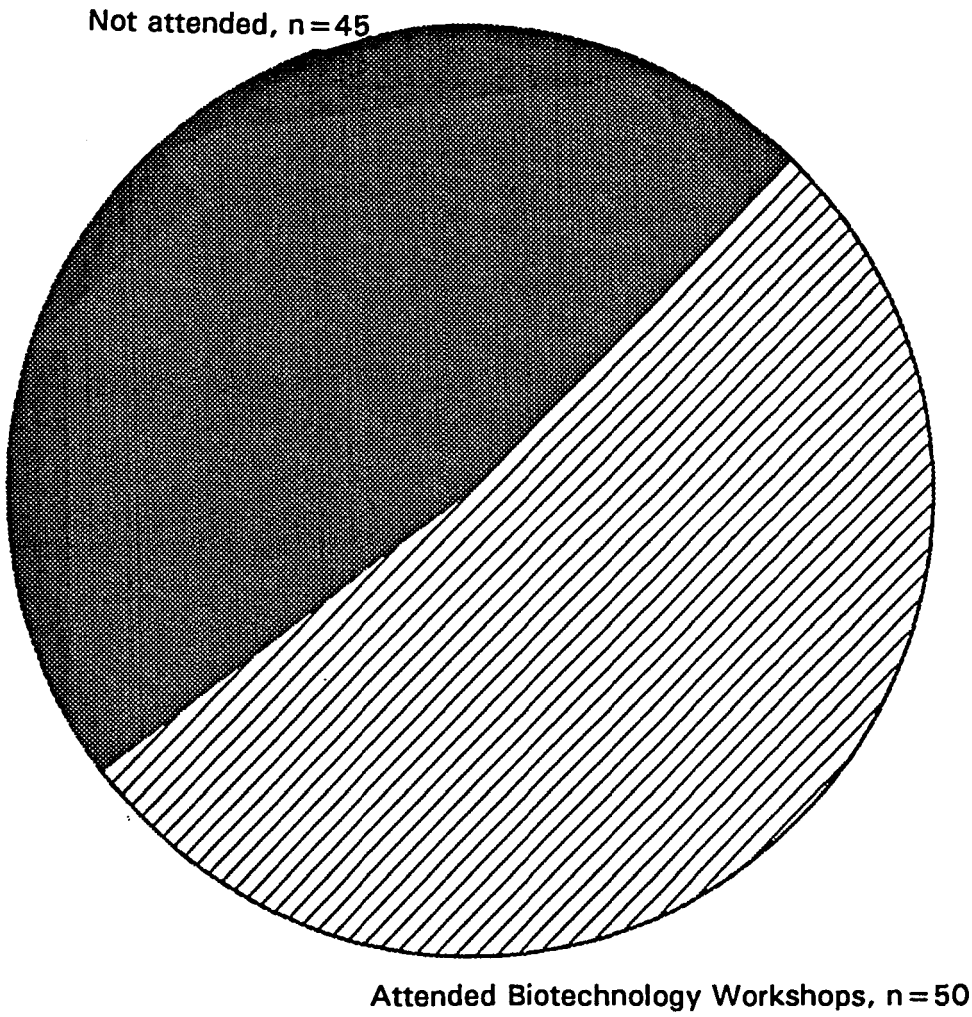

Figure 7. Iowa Agricultural Extension Agents indicating attendance at a biotechnology workshop, conference, or course (n=95)

Perceptions Regarding the Need for Training

This section describes the perceived need for training in 23 topical items associated with biotechnology, as indicated by the Iowa Agricultural Extension Agents responding to the survey. The respondents were asked to indicate their level of agreement with the need for training regarding the topical items associated with biotechnology. The items were scored on a five-point Likert-type scale where 1 indicated "strongly disagree," 2 indicated "disagree," 3 indicated "neutral," 4 indicated "agree," and 5 indicated "strongly agree." The means and standard deviations of the level of agreement regarding training needs in the topical items as perceived by the respondents are listed in descending order in Table 2.

Overall, the topic areas displayed in Table 3 received a mean score rating from 3.00 (neutral) to 4.00 (agree), which indicate the perceived level of agreement of Iowa Agricultural Extension Agents regarding training needs in biotechnology. The lowest mean score was 3.21 (neutral), and the highest mean score was 4.22 (agree), indicating either a neutral stance regarding training needs, to agreement that training was needed in certain topical areas. The respondents did not score any item below a 3.00 (neutral); thus, there was no disagreement with the need for training in each of the topics associated with biotechnology was used in this questionnaire.

Table 4 displays the seven topics with means greater than 4.00 (agree), suggesting that the agents surveyed agreed that training was needed in these topic areas. "Disease and pest resistant crop varieties" had the highest mean rating ($\bar{x}$=4.22). The second highest rated item

Table 3. Means and standard deviations regarding the perceived need for training in each of the topic areas in biotechnology by Iowa Agricultural Extension Agents responding (N=95)

Rank	Item	Mean[a]	S.D.
1	Disease and Pest Resistant Crop Varieties	4.22	0.90
2	Herbicide Resistant Crop Varieties	4.16	0.93
3	Economic Implications of Biotechnology	4.11	0.82
4	Disease Resistance in Livestock	4.05	0.90
5	New Crop Varieties	4.03	0.99
6	New Uses for Crop and Livestock Products	4.02	0.92
7	Biological Control of Pests	4.02	0.94
8	Growth Regulators	3.97	0.86
9	Using Porcine Somatotropin (PST) in Pork Production	3.96	1.04
10	Environmental Impacts of Biotechnology	3.95	0.87
11	New Uses for Agricultural By-Products	3.92	0.84
12	Corn Varieties That Fix Own Nitrogen	3.90	1.00
13	Risk Assessment of Biotechnology	3.90	0.86
14	Social Implications of Biotechnology	3.81	0.96
15	Diagnostic Kits Using Biotechnology	3.73	0.84
16	Bioethics	3.72	0.93
17	Policy Implications of Biotechnology	3.72	0.92
18	Using Bovine Somatotropin (BST) in Dairy	3.70	1.17
19	Genetic Engineering	3.46	0.94
20	Cloning	3.26	0.97
21	Gene Insertion	3.24	0.97
22	Recombinant DNA	3.22	0.98
23	Tissue Culture	3.21	1.03

[a]Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

was "herbicide resistant crop varieties" ($\bar{x}$=4.17). The third highest rated item was "economic implications of biotechnology" ($\bar{x}$=4.12). This item also had the lowest variability with a standard deviation of 0.82. The fourth, fifth, sixth, and seventh highest rated items were "disease resistance in livestock" ($\bar{x}$=4.05), "new crop varieties" ($\bar{x}$=4.03), "new

Table 4. Highest rated topics in biotechnology based on training needs as perceived by Iowa Agricultural Extension Agents (n=95)

Topic	Mean[a]	S.D.
Disease and Pest Resistant Crop Varieties	4.22	0.90
Herbicide Resistant Crop Varieties	4.16	0.93
Economic Implications of Biotechnology	4.11	0.82
Disease Resistance in Livestock	4.05	0.90
New Crop Varieties	4.03	0.99
New Uses for Crop and Livestock Products	4.02	0.82
Biological Control of Pests	4.02	0.94

[a]Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

uses for crop and livestock products" ($\bar{x}$=4.02), and "biological control of pests" ($\bar{x}$=4.02), respectively.

The next eleven items were rated between means of 3.71 and 3.91 (agree). Table 5 displays the five topics that scored means below 3.500, suggesting a neutral level of agreement as far as training needs as expressed by Agricultural Extension Agents in Iowa to these topic areas. The lowest rated item was "tissue culture." The second lowest rated item was "recombinant DNA." The third, fourth, and fifth lowest rated items were "gene insertion," "cloning," and "genetic engineering," respectively.

Table 6 displays significant statistical differences between the age groups of the respondents and their perceived need for training regarding certain topic areas in biotechnology. The topic "New Uses for Crop and Livestock Products" indicated significant differences between group 1 (26-35 years of age) and group 2 (36-45 years of age), between group 1 and group 3 (46-55 years of age), and between group 1 and group 4 (56-65 years

Table 5. Topics in biotechnology with means less than 3.50 regarding training needs as perceived by Iowa Agricultural Extension Agents (n=95)

Topic	Mean[a]	S.D.
Tissue Culture	3.21	1.03
Recombinant DNA	3.22	0.98
Gene Insertion	3.24	0.97
Cloning	3.26	0.97
Genetic Engineering	3.26	0.94

[a]Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

of age). Group 1 rated this topic significantly lower than the other three age groups. The topic "Economic Implications of Biotechnology" showed significant differences between group 2 (36-46 years of age) and group 3 (46-55 years of age) and between group 2 and group 4 (56-65 years of age), with group 2 rating this item significantly lower than group 3 and group 4. The topic "Policy Implications of Biotechnology" found a significant difference between group 3 (46-55 years of age) and group 1 (26-35 years of age) and between group 3 and group 2 (36-46 years of age), with group 3 being rated significantly higher than groups 1 and 2 for the topic "Policy Implications of Biotechnology." The topic "Social Implications of Biotechnology" showed a significant difference between group 1 (26-35 years of age) and group 3 (46-55 years of age). Group 3 rated "Social Implications of Biotechnology" significantly higher than group 1.

Table 6. Significant differences in means, standard deviations and F-values regarding the respondents' perceived need for training in selected topics in biotechnology when grouped by age

Topic	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3 n	Group 3 Mean S.D.	Group 4[a] n	Group 4[a] Mean S.D.	F-value	F-prob.
New uses for crop and livestock products	17	3.53 0.87	29	4.03 0.94	36	4.17 0.70	13	4.23 0.60	2.83*[b]	.0431
Economic implications of biotechnology	17	3.88 1.05	29	3.86 0.79	36	4.31 0.75	13	4.46 0.52	2.95*[c]	.0370
Policy implications of biotechnology	17	3.41 0.87	29	3.55 0.95	36	4.01 0.86	13	3.62 0.96	2.71*[d]	.0498
Social implications of biotechnology	17	3.35 1.06	29	3.69 0.97	36	4.11 0.82	13	3.85 0.99	2.77*[e]	.0459

[a]Group 1 = 26-35 years of age; group 2 = 36-45 years of age; group 3 = 46-55 years of age; group 4 = 56-65 years of age.

[b]Significant differences exist between groups 1 and 2, between groups 1 and 3, and between groups 1 and 4.

[c]Significant differences exist between groups 2 and 3 and between groups 2 and 4.

[d]Significant differences exist between groups 1 and 3 and between groups 2 and 3.

[e]Significant differences exist between groups 1 and 3.

*Significant at the 0.05 level.

There were no statistical differences found between the respondents' perceived need for training and their years of experience in extension.

Table 7 indicates the topical item that exhibited a statistically significant difference between the respondents' educational level and their perceived need for training in selected topics in biotechnology. The topic "Disease Resistance in Livestock" indicated significant differences occurred between group 3 (Doctoral Degree) and group 1

Table 7. Significant differences in means, standard deviations and F-values regarding respondents' perceived need for training in selected topics in biotechnology when grouped by educational level

Topic	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3[a] n	Group 3[a] Mean S.D.	F-value	F-prob.
Disease resistance in livestock	17	4.29 0.69	71	4.08 0.86	7	3.14 1.35	4.51*[b]	.0135

[a]Group 1 = Bachelor's Degree; group 2 = Master's Degree; group 3 = Doctoral Degree.

[b]Significant differences exist between groups 1 and 3 and between groups 1 and 2.

*Significant at the 0.05 level.

(Bachelor's Degree) and between group 3 and group 2 (Master's Degree). Group 3 rated "Disease Resistance in Livestock" significantly lower than groups 1 and 2.

Table 8 presents the significant statistical differences between the respondents' perceived need for training in selected topics in biotechnology and the extension administrative area in which they worked. The topic "Biological Control of Pests" exhibited a statistically significant difference between group 4 (Northwest) and group 2 (Southwest) and between group 4 and group 3 (Northeast). Group 3 rated "Biological Control of Pests" significantly lower than groups 2 and 3. The topic item "New Uses for Agricultural By-Products" indicated significant statistical differences between group 3 (Northeast) and group 4 (Northwest), between group 6 (Central) and group 1 (Southeast), between group 6 and group 2

Table 8. Significant differences in means, standard deviations and F-values regarding respondents' perceived need for training in selected topics in biotechnology when grouped by extension administration area

Topic	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3 n	Group 3 Mean S.D.	Group 4 n	Group 4 Mean S.D.	Group 5 n	Group 5 Mean S.D.	Group 6 n	Group 6 Mean S.D.	Group 7[a] n	Group 7[a] Mean S.D.	F-value	F-prob.
Biological control of pests	13	3.92 0.95	16	4.50 0.63	16	4.25 0.68	11	3.27 1.42	14	3.93 0.92	11	3.91 0.94	14	4.07 0.83	2.23*[b]	.0473
New uses for agricultural by-products	13	3.77 1.17	16	3.81 0.65	16	4.21 0.62	11	3.36 0.92	14	3.79 0.80	11	4.55 0.52	14	4.00 0.78	2.40*[c]	.0337
Social implications of biotechnology	13	3.00 0.91	16	4.06 0.77	16	4.00 0.89	11	4.00 1.00	14	4.00 0.78	11	3.55 0.93	14	3.36 0.93	2.98*[d]	.0107

[a]Group 1 = Southeast; group 2 = Southwest; group 3 = Northeast; group 4 = Northwest; group 5 = North Central; group 6 = Central; and group 7 = East Central.

[b]Significant differences exist between groups 2 and 4 and between groups 3 and 4.

[c]Significant differences exist between groups 3 and 4, between groups 1 and 6, between groups 2 and 6, between groups 4 and 6, and between groups 5 and 6.

[d]Significant differences exist between groups 1 and 2, between groups 1 and 3, between groups 1 and 4, and between groups 1 and 5.

*Significant at the 0.05 level.

(Southwest), between group 6 and group 4, and between group 6 and group 5 (North Central). Group 3 rated the topic "New Uses for Agricultural By-Products" significantly higher than group 4, and group 6 rated this topic significantly higher than groups 1, 2, 4, and 5. The item "Social Implications of Biotechnology" indicated a significant statistical difference between group 1 (Southeast) and group 2 (Southwest), between group 1 and group 3 (Northeast), between group 1 and group 4 (Northwest), and between group 1 and group 5 (North Central). Group 1 rated the topic "Social Implications of Biotechnology" significantly lower than groups 2, 3, 4, and 5 in regard to training needs.

Table 9 displays the significant statistical differences existing between the respondent's position employed with extension and the perceived need for training in selected topics in biotechnology. The topics "New Crop Varieties," "Disease and Pest Resistant Crop Varieties," "Disease Resistance in Livestock," and "Biological Control of Pests" exhibited statistical differences between group 1 (County Agriculturalists) and group 2 (Area Agricultural Specialists), with group 1 rating these topics significantly higher than group 2.

Perceptions Regarding the Need for Informational Materials

This section describes the perceived need for informational materials in 23 topical items associated with biotechnology as indicated by the Iowa Agricultural Extension Agents responding to the survey. The respondents were asked to indicate their level of agreement with the need for informational materials on the topical items associated with

Table 9. Significant differences in means and t-values regarding respondents' perceived need for training in selected topics in biotechnology when grouped by employee position in extension (n=95)

Topic	Group 1		Group 2[a]		t-value
	n	Mean	n	Mean	
New crop varieties	73	4.16	22	3.59	2.43*
Disease and pest resistant crop varieties	73	4.36	22	3.77	2.80**
Disease resistance in livestock	73	4.18	22	3.64	2.50*
Biological control of pests	73	4.14	22	3.64	2.22*

[a]Group 1 = County Agriculturist; 2 = Area Agricultural Specialist.
*Significant at the 0.05 level.
**Significant at the 0.01 level.

biotechnology. The items were rated on a five-point Likert-type scale where 1 indicated "strongly disagree"; 2 indicated "disagree"; 3 indicated "neutral"; 4 indicated "agree"; and 5 indicated "strongly agree." The means and standard deviations of the level of agreement regarding informational material needs on the topical items as perceived by the respondents are listed in descending order in Table 10.

Overall, the topical items displayed in Table 10 received a mean score rating from 3.00 (neutral) to 4.00 (agree), which were indicative of the perceived level of agreement of Iowa Agricultural Extension Agents regarding informational needs of these topics in biotechnology. The lowest mean score was 3.29 (neutral) and a high mean score of 4.33 (agree), indicating either a neutral stance regarding informational needs to agreement that informational material is needed in these topical areas.

Table 10. Means and standard deviations ranked in descending order regarding the perceived need for informational materials in each of the topical items in biotechnology by the Iowa Agricultural Extension Agents responding (n=95)

Rank	Item	Mean[a]	S.D.
1	Disease and Pest Resistant Crop Varieties	4.33	0.82
2	Biological Control of Pests	4.31	0.86
3	Herbicide Resistant Crop Varieties	4.30	0.81
4	New Crop Varieties	4.27	0.91
5	New Uses for Crop and Livestock Products	4.23	0.84
6	Economic Implications of Biotechnology	4.17	0.82
7	Disease Resistance in Livestock	4.16	0.79
8	Using Porcine Somatotropin (PST) in Pork Production	4.16	0.93
9	Environmental Impacts of Biotechnology	4.11	0.86
10	Growth Regulators	4.10	0.85
11	New Uses for Agricultural By-Products	4.08	0.90
12	Risk Assessment of Biotechnology	4.04	0.82
13	Corn Varieties That Fix Own Nitrogen	4.04	0.97
14	Using Bovine Somatotropin (BST) in Dairy	3.98	0.99
15	Diagnostic Kits Using Biotechnology	3.88	0.92
16	Social Implications of Biotechnology	3.87	0.90
17	Bioethics	3.84	0.94
18	Policy Implications of Biotechnology	3.84	0.96
19	Genetic Engineering	3.63	1.02
20	Cloning	3.45	0.94
21	Recombinant DNA	3.34	0.98
22	Tissue Culture	3.32	1.00
23	Gene Insertion	3.29	1.03

[a]Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

The respondents did not score any item below a 3.00 (neutral); thus, there was no disagreement with the need for informational material in each of the topics associated with biotechnology used in this questionnaire.

Table 11 indicates the eight topics with means greater than 4.15 (agree), suggesting that the agents surveyed agreed that training was

Table 11. Topics in biotechnology with the highest mean values regarding informational needs as perceived by Iowa Agricultural Extension Agents (n=95)

Topic	Mean[a]	S.D.
Disease and Pest Resistant Crop Varieties	4.33	0.82
Biological Control of Pests	4.31	0.86
Herbicide Resistant Crop Varieties	4.30	0.81
New Crop Varieties	4.27	0.91
New Uses for Crop and Livestock Products	4.23	0.84
Economic Implications of Biotechnology	4.17	0.82
Disease Resistance in Livestock	4.16	0.79
Using Porcine Somatotropin in Pork Production	4.16	0.93

needed in these areas. "Disease and pest resistant crop varieties" ($\bar{x}$=4.34) scored the highest mean rating and had a low variability with a standard deviation of 0.82. The second highest rated item was "biological control of pests" ($\bar{x}$=4.32). The third highest rated item was "herbicide resistant crop varieties" ($\bar{x}$=4.31). This item also had a low variability with a standard deviation of 0.81. The fourth, fifth, sixth, seventh, and eighth highest rated items were "new crop varieties" ($\bar{x}$=4.27), "new uses for crop and livestock products" ($\bar{x}$=4.23), "economic implications of biotechnology" ($\bar{x}$=4.18), "disease resistance in livestock" ($\bar{x}$=4.17), and "using porcine somatotropin (PST) in pork production" ($\bar{x}$=4.17), respectively.

The next twelve items were rated between means of 3.63 and 4.11 (agree). Table 12 displays the four topics that scored means below 3.50, suggesting a neutral level of agreement regarding informational needs on

Table 12. Topics in biotechnology with the lowest mean values regarding informational needs as perceived by Iowa Agricultural Extension Agents (n=95)

Topic	Mean[a]	S.D.
Gene Insertion	3.29	1.03
Tissue Culture	3.32	1.00
Recombinant DNA	3.34	0.98
Cloning	3.45	0.94

[a]Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

these topics as expressed by Agricultural Extension Agents in Iowa. The lowest rated item was "gene insertion" ($\bar{x}$=3.30). The second lowest rated item was "tissue culture" ($\bar{x}$=3.32). The third lowest rated item was "recombinant DNA" ($\bar{x}$=3.35). The fourth lowest rating was "cloning" ($\bar{x}$=3.45).

Table 13 displays significant statistical differences between the age groups of the respondents and their perceived need for informational materials regarding certain topical items in biotechnology. The topic "Disease and Pest Resistant Crop Varieties" indicated a significant statistical difference between group 2 (36-45 years of age) and group 1 (26-35 years of age), between group 2 and group 3 (46-55 years of age), and between group 2 and group 4 (56-65 years of age). Group 2 rated the topic "Disease and Pest Resistant Crop Varieties" lower than groups 1, 3, and 4. The topic "Economic Implications of Biotechnology" exhibited a significant difference between group 2 (36-45 years of age) and group 3 (46-55 years of age) and group 2 and group 4 (56-65 years of age). Group

Table 13. Significant differences in means, standard deviations and F-values regarding the respondents' perceived need for informational materials in selected topics in biotechnology when grouped by age

Topic	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3 n	Group 3 Mean S.D.	Group 4[a] n	Group 4[a] Mean S.D.	F-value	F-prob.
Disease and pest resistant crop varieties	17	4.47 0.72	29	3.97 1.02	36	4.47 0.65	13	4.54 0.66	2.90*[b]	.0394
Economic implications of biotechnology	17	4.18 0.88	29	3.72 0.92	36	4.36 0.68	13	4.54 0.52	4.80**[c]	.0038
Social implications of biotechnology	17	3.88 0.93	29	3.48 1.02	36	4.14 0.64	13	3.85 0.99	3.05*[d]	.0327
Bioethics	17	3.88 1.05	29	3.38 0.94	36	4.11 0.78	13	3.92 0.95	3.59*[e]	.0167

[a]Group 1 = 26-35 years of age; group 2 = 36-45 years of age; group 3 = 46-55 years of age; group 4 = 56-65 years of age.
[b]Significant differences exist between groups 1 and 2, between groups 2 and 3, and between groups 2 and 4.
[c]Significant differences exist between groups 2 and 3 and between groups 2 and 4.
[d]Significant differences exist between groups 2 and 3.
[e]Significant differences exist between groups 2 and 3.
*Significant at the 0.05 level.
**Significant at the 0.01 level.

2 rated the topic "Economic Implications of Biotechnology" significantly lower than groups 3 and 4. The topics "Social Implications of Biotechnology" and "Bioethics" indicated significant differences between group 2 (36-45 years of age) and group 3 (46-55 years of age), with group 2 rating these two topics significantly lower than group 3.

A significant statistical difference was found between the respondents' perceived need for informational material regarding the topic "Economic Implications of Biotechnology" when grouped by years of experience in extension. Group 4 (over 31 years of experience) rated the topic "Economic Implications of Biotechnology" significantly higher than group 1 (0-10 years of experience).

Table 14 presents significant statistical differences between the educational level of respondents and their perceived need for

Table 14. Significant differences in means, standard deviations and F-values regarding respondents' perceived need for informational material in selected topics in biotechnology when grouped by educational level

Topic	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3[a] n	Group 3[a] Mean S.D.	F-value	F-prob.
Using porcine somatotropin (PST) in pork production	17	4.24 1.15	71	4.24 0.82	7	3.29 1.11	3.59*[b]	.0315
Using bovine somatotropin (BST) in dairy	17	4.00 1.22	71	4.08 0.87	7	3.00 1.15	4.03*[c]	.0209
Disease resistance in livestock	17	4.18 1.01	71	4.25 0.62	7	3.14 1.07	7.13**[d]	.0013

[a]Group 1 = Bachelor's Degree; 2 = Master's Degree; 3 = Doctoral Degree.

[b]Significant differences exist between groups 1 and 2 and between groups 2 and 3.

[c]Significant differences exist between groups 1 and 2 and between groups 2 and 3.

[d]Significant differences exist between groups 1 and 2 and between groups 2 and 3.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

informational materials in selected topics of biotechnology. The topics "Using Porcine Somatotropin (PST) in Pork Production," "Using Bovine Somatotropin (BST) in Dairy," and "Disease Resistance in Livestock" exhibited significant differences between group 3 (Doctoral Degree) and group 1 (Bachelor's Degree) and group 3 and group 2 (Master's Degree). Group 3 rated these three topics significantly lower than groups 1 and 2 in regard to the need for informational materials.

A significant statistical difference was found between the respondents' perceived need for informational material pertaining to the topic "New Crop Varieties" and the extension administrative area in which they work. Group 4 (Northwest) rated the topic "New Crop Varieties" significantly lower than groups 1 (Southeast), 2 (Southwest), 3 (Northeast), 5 (North Central), 6 (Central), and 7 (East Central).

A significant difference was also found between the respondents' perceived need for informational material in the topic "Corn Varieties that Fix Own Nitrogen" and their employee position in Extension. Group 1 (County Agriculturists) rated this topic significantly higher than group 2 (Area Agricultural Specialists).

Perceptions Regarding Biotechnology Statements

This section describes the perceptions of Iowa Agricultural Extension Agents regarding selected statements pertaining to biotechnology. In this section of the survey instrument, respondents were asked to indicate their level of agreement with statements pertaining to bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education in the agricultural and public

sectors. The statements were rated on a five-point Likert-type scale where 1 indicated "strongly disagree"; 2 indicated "disagree"; 3 indicated "neutral"; 4 indicated "agree"; and 5 indicated "strongly agree". In describing the findings from this section of the survey, the statements have been grouped into the following three areas: (1) bioethics, (2) biotechnology's potential impact on agriculture, and (3) Extension's role in biotechnology education.

The means and standard deviations of the level of agreement with statements pertaining to bioethics as perceived by the respondents are presented in Table 15. Three statements had mean scores of 4.00 (agree) or higher, with the statement "consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the 'end-product'" having the highest mean score ($\bar{x}$=4.17). The respondents somewhat disagreed with the statement "advances made with biotechnology in genetic engineering will have no effect or have implications towards human genetic engineering" ($\bar{x}$=2.07).

Table 16 displays significant statistical differences between the age groups of the respondents and their perceptions of statements regarding bioethics. The statements "Advances made with biotechnology in genetic engineering will have no effect or have implications towards human genetic engineering" and "Consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the 'end-product'" indicated significant differences between group 4 (56-65 years of age) and group 2

Table 15. Means and standard deviations of level of agreement regarding statements pertaining to bioethics as perceived by Iowa Agricultural Extension Agents (n=95)

Topics	Mean[a]	S.D.
Consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the "end-product."	4.20	0.97
Using biotechnology to improve agricultural crops and livestock production is moral and ethical.	4.16	0.95
Risk assessment should be a primary component of agricultural biotechnology research.	4.00	1.10
Consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality.	3.10	1.14
Advances made with biotechnology in genetic engineering will have no effect or have implications towards human genetic engineering.	2.07	1.04

[a]Scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree.

(36-45 years of age) and group 4 and group 3 (46-55 years of age). Group 4 rated their level of agreement of these two statements significantly higher than groups 2 and 3.

Table 17 presents the significant statistical differences between the respondents' employed position in extension and their perceived level of agreement with the statement "Consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality." Group 1 (County Agriculturists) rated its

Table 16. Significant differences in means, standard deviations, and F-values regarding respondents' perceived level of agreement with statements pertaining to bioethics when grouped by age

Statement	Group 1 n	Group 1 Mean S.D.	Group 2 n	Group 2 Mean S.D.	Group 3 n	Group 3 Mean S.D.	Group 4[a] n	Group 4[a] Mean S.D.	F-value	F-prob.
Allowances made in biotechnology in genetic engineering will have no effect or implications towards human human genetic engineering.	17	1.82 1.13	29	1.55 0.74	36	1.72 0.78	13	2.46 1.15	2.84*[b]	.0421
Consumers will greatly influence the adoption of innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the "end-product."	17	3.82 1.13	29	4.00 0.96	36	4.22 0.87	13	3.31 0.85	3.12*[c]	.0300

[a]Group 1 = 26-35 years of age; group 2 = 36-45 years of age; group 3 = 46-55 years of age; and group 4 = 56-65 years of age.

[b]Significant differences exist between groups 2 and 4 and between groups 3 and 4.

[c]Significant differences exist between groups 2 and 4 and between groups 3 and 4.

*Significant at the 0.05 level.

agreement with this statement significantly lower than group 2 (Area Agricultural Specialists).

There were no significant statistical differences found between the respondent's perceived level of agreement to statements pertaining to

Table 17. Significant differences in means and t-values regarding respondents' perceived level of agreement with statements pertaining to bioethics when grouped by employed position in Extension

Statement	Group 1 n	Group 1 Mean	Group 2[a] n	Group 2[a] Mean	t-value
Consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality.	73	3.03	22	2.45	2.10*

[a]Group 1 = County Agriculturist; group 2 = Area Agricultural Specialist.

*Significant at the 0.05 level.

bioethics and their gender, years of experience in extension, educational level, or extension administrative area.

The means and standard deviations of the level of agreement with statements pertaining to biotechnology's potential impact on agriculture are displayed in Table 18. Of these twelve statements, only one had a mean score higher than 4.00 (somewhat agree), and four statements had mean values between 3.50 and 3.99, indicating a level of agreement from a neutral stance to somewhat agree. The statement "biotechnology will produce plant varieties and livestock species that are more resistant to disease and pests" rated the highest mean ($\bar{x}$=4.06). The second highest mean score was the statement "economic gains will be realized from the early adoption of growth promotants (PST;BST)" ($\bar{x}$=3.66). The third highest mean rating was the statement "biotechnology will lead farmers to become more dependent upon large corporations for many of their inputs,

Table 18. Means and standard deviations of level of agreement regarding statements pertaining to biotechnology's potential impact on agriculture as perceived by Iowa Agricultural Extension Agents (n=95)

Topics	Mean[a]	S.D.
Biotechnology will produce plant varieties and livestock species that are more resistant to disease and pests.	4.06	0.86
Economic gains will be realized from the timely adoption of growth promotents (PST;BST).	3.66	0.88
Biotechnology will lead farmers to become more dependent upon large corporations for many of their inputs, such as seeds, growth hormones, and feed additives.	3.65	0.93
Biotechnology will assist the development of sustainable agriculture.	3.60	0.89
Biotechnology will produce biological controls for pests that are reliable and economical.	3.55	0.79
Biotechnology will cause overproduction and surpluses of agricultural commodities.	3.14	0.87
Biotechnology will help solve the problem of farm surpluses by finding new uses for crops, livestock, and their by-products.	3.04	0.95
Biotechnology will improve the economic stability of farm families and bring improved levels of living.	2.89	0.81
Biotechnology will have an adverse effect on the environment.	2.29	0.92
Biotechnology will cause farmers to become more dependent upon agricultural chemicals.	2.28	0.89
Advances in biotechnology will probably benefit diversified farms more than specialized farm operations.	2.04	0.91

[a]Scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree.

Table 18. (Continued)

Topics	Mean[a]	S.D.
Advances in biotechnology will probably benefit persons with middle-sized and small farm operations more than persons with large farms.	1.98	0.85

such as seeds, growth hormones, and feed additives" ($\bar{x}$=3.65). The fourth highest mean rating was the statement "Biotechnology will assist the development of sustainable agriculture" ($\bar{x}$=3.60). The fifth highest mean rating was the statement "biotechnology will produce biological controls for pests that are reliable and economical" ($\bar{x}$=3.56).

Three statements were rated between 2.50 and 3.49 (neutral). The lower mean scores indicate statements where respondents somewhat disagreed. Respondents disagreed with the statement "Advances in biotechnology will probably benefit persons with middle-sized and small farm operations more than persons with large farms," which had the lowest mean score ($\bar{x}$=1.99). The next lowest mean score was the statement "advances in biotechnology will probably benefit diversified farms more than specialized farm operations" ($\bar{x}$=2.04). The third lowest mean score was the statement "biotechnology will cause farmers to become more dependent upon agricultural chemicals" ($\bar{x}$=2.28). The fourth lowest mean score was the statement "biotechnology will have an adverse effect on the environment" ($\bar{x}$=2.30).

Table 19 shows the significant statistical differences between the educational level of the respondent and their perceived level of agreement

Table 19. Significant differences in means, standard deviations, and F-values regarding respondents' perceived level of agreement with statements pertaining to biotechnology's potential impact on agriculture when grouped by educational level

Statement	Group 1 n	Mean S.D.	Group 2 n	Mean S.D.	Group 3[a] n	Mean S.D.	F-value	F-prob.
Biotechnology will lead farmers to become more dependent on large corporations for many of their inputs, such as seed, growth hormones, and feed additives.	17	2.18 0.95	71	2.45 0.92	7	1.57 0.79	3.23*[b]	.0441

[a]Group 1 = Bachelor's Degree; group 2 = Master's Degree; group 3 = Doctoral Degree.
[b]Significant differences exist between groups 2 and 3.
*Significant at the 0.05 level.

to statements regarding biotechnology's potential impact on agriculture. The statement "Biotechnology will lead farmers to become more dependent upon large corporations for many of their inputs, such as seeds, growth hormones, and feed additives" indicated a significance between group 2 (Master's Degree) and group 3 (Doctoral Degree). Group 2 rated their perceived level of agreement to this statement higher than group 3.

Table 20 displays the significant statistical differences between the respondents' employee position in Extension to their perceived level of agreement with the statement "Biotechnology will produce biological controls for pests that are reliable and economical." Group 1 (County Agriculturists) rated their level of agreement significantly lower than group 2 (Area Agricultural Specialists).

Table 20. Significant differences in means and t-values regarding respondents' perceived level of agreement with statements pertaining to bio-technology's potential impact on agriculture when grouped by employed position in Extension

Statement	Group 1 n	Group 1 Mean	Group 2[a] n	Group 2[a] Mean	t-value
Biotechnology will produce controls that are reliable and economical	73	2.36	22	2.73	4.81**

[a]Group 1 = County Agriculturists; group 2 = Area Agricultural Specialists.

**Significant at the 0.01 level.

There were no significant statistical differences found between the respondents' perceived level of agreement to statements regarding biotechnology's potential impact on agriculture and their gender, age, years of experience in Extension, or extension administrative area.

The level of agreement with statements pertaining to Extension's role in biotechnology education as perceived by the Iowa Agricultural Extension Agents is described in Table 21. All three statements had mean scores over 4.00 (somewhat agree).

There were no significant statistical differences found between the respondents' perceived level of agreement to statements regarding Extension's role in biotechnology education and their age, years of experience in extension, educational level, extension administrative area, or employee position in extension.

Table 21. Means and standard deviations of level of agreement regarding statements pertaining to Extension's role in biotechnology education as perceived by Iowa Agricultural Extension Agents (n=95)

Topics	Mean[a]	S.D.
Extension should be very involved with biotechnology in regard to applied research, technology transfer, and innovation-adoption.	4.12	1.17
Extension state and field specialists should be actively involved in applied research at on-farm sites throughout the state.	4.07	1.12
Extension will play a critical role in educating the general public and addressing "public perceptions" regarding biotechnology in agriculture.	4.02	1.14

[a]Scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree.

Comments by Respondents

The questionnaire provided respondents with an opportunity to add their own thoughts or comments about the contents of the questionnaire, specifically their opinion on the leadership role Extension should play in agricultural biotechnology. Comments contained in this section were from both completed and uncompleted questionnaires which were returned. The comments and opinions expressed by Agricultural Extension Agents regarding Extension's role in agricultural biotechnology are listed as follows:

> We need time to attend training and still meet our work expectations.
>
> A must do topic.
>
> I think it is an important area to agriculture and one in which Extension can be involved. I also think it will be much

more difficult to launch a comprehensive effort in the area under the new structure.

We need to be involved and provide leadership.

Let's get our staff trained.

Education and demonstration through Extension is vital to all advances in biotechnology.

As in other phases of education, we need data and then training to take to the clients.

Extension needs to begin involvement and education on the area and local level to a greater degree than we are presently.

I suppose biotech will continue. I am against many of the things currently being conducted under the biotech heading. Biotech will HURT the mid- to small size family farm.

With ISU being in the forefront with biotechnology research, we as the outreach organization of the university need to be very aggressive and active in getting the information about biotech to the people of Iowa.

I question if staff time will be available to do it.

Biotech will be only as important as the usefulness of its end products. Extension's role is to transfer technology to those who can use it in the field. It should make no difference if that technology is a product of biotechnology or traditional research.

Probably greater need for informational material to hand out to persons who request (students, etc.). Not sure we need to spend time in training because won't have time in the new reorganization.

Yes, Extension needs to be in a leading role, but we must also be careful about promoting the technology before society is ready to accept it. There will be some extremely useful benefits from biotechnology, but also some very dangerous/immoral potential situations coming from adoption.

Walt Fehr does a tremendous job in explaining biotech to lay people.

Because of the wide range in clientele expertise and understanding of scientific information our role needs to be clearly defined as to which group or level should we target.

Once defined, what do we take off our plates that are already overflowing.

Don't know that much about it at present.

We need to be there if it is going to mean more profit or survival for farmers--as long as determined ethical.

Should have more in-service on this!

Extension field staff should become informed and comfortable with subject matter and issues so they can give leadership to disseminating facts and information to educate the clientele.

Biotechnology is a new area of research at ISU. We must provide a general public education program to consumers and producers.

Biotech development will advance rapidly, despite any social/ethical concerns of society.

Extension needs to get up to speed very rapidly on this changing technology. Its potential impact is very large.

The Extension Service must take the lead in presenting educational information on Biotechnology.

I feel urban counties can help to inform consumers on food safety and environmental concerns of biotech.

We need to be on the cutting edge of this issue since it will have major impacts for all walks of life, not just agriculture.

This is our responsibility.

Extension should extend the research to the people of Iowa and the world.

Extension should lead education--I doubt it ever will.

All the good things in the world will fail if public perception is negative. We must instill confidence that the technology is safe.

Extension should be on the cutting edge of providing information to clientele throughout Iowa in the area of biotechnology.

> Extension needs to be sensitive to perceptions of mistrust. Many feel the long-term effects of biotech will be the end of the family farm. We need to play the middle man and help sort out facts. We must not be linked to private firms with a vested economic interest in biotech.
>
> For ISU and ISU Extension not to aggressively pursue a leadership role in biotechnology would be a monumental blunder.
>
> Some of the topics in section 1 are not yet to the level to require training, but will in the next few years.
>
> I feel most of the biotech developments will be invisible to the producer. Knowledge of biotech will not be necessary to use it.
>
> Extension has a strong role in technology transfer and also in providing a forum to discuss the economic, social, legal, and ethical input of biotech. This was our approach in the Iowa and the Global Economy Series.
>
> We need to help producers assess these new technologies and how they may fit into their production system.

An analysis of the comments made by respondents indicated that as a group they view biotechnology as an important topic and ISU Extension should be involved with the educational aspect of biotechnology. Several respondents indicated the need for training and informational materials to educate themselves and clientele about biotechnology. Several comments indicated that ISU Extension should provide leadership in biotechnology. Many respondents cited a lack of time available to spend on biotechnology research and education, and question how it will fit into the new Iowa State University Extension structure.

CHAPTER V. DISCUSSION OF THE FINDINGS

The overall purpose of this study was to identify the perceptions of Iowa Agricultural Extension Agents regarding training and informational needs relating to biotechnology, as well as perceptions towards bioethics, biotechnology's potential impact on agriculture, and Extension's role in education concerning biotechnology.

The specific objectives of this study were:

1. To identify the level of importance of agricultural biotechnology as perceived by Iowa Agricultural Extension Agents.
2. To determine the extent of training needed as perceived by Iowa Agricultural Extension Agents regarding various topical areas in biotechnology.
3. To determine the degree of importance relating to informational material needed by Iowa Agricultural Extension Agents regarding various topical areas in biotechnology.
4. To identify perceptions held by Iowa Agricultural Extension Agents in regard to bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education in the agricultural and public sectors.
5. To compare perceived differences existing in Iowa Agricultural Extension Agents regarding agricultural biotechnology according to various demographic factors.

The findings of this study are discussed in this chapter as they relate to the stated objectives. Overall, the respondents indicated that

biotechnology is an important topic, and training and informational materials are needed to help "extend" this technology to the agricultural and public sectors. Comments made by respondents that support this remark include "with ISU being in the forefront with biotechnology research, we as the outreach organization of the university need to be very aggressive and active in getting the information about biotech to the people of Iowa," "a must do topic," and "let's get our staff trained." Another comment by a respondent that also relates to the importance of biotechnology education stated, "We need to be on the cutting edge of this issue since it will have major impacts for all walks of life, not just agriculture."

This chapter is discussed and organized under the following sub-headings: (1) Demographic characteristics of the respondents; (2) Perceived training needs of respondents in biotechnology; (3) Perceived informational material needs of respondents in biotechnology; (4) Perceived level of agreement of respondents to statements about biotechnology; (5) Comments made by respondents; and (6) Educational implications of the findings of the study.

Demographic Characteristics of the Respondents

A typical profile of an Iowa Agricultural Extension Agent would be "male, 45 years of age, Master's Degree, with 15 years of experience in the Cooperative Extension Service." The study found that the respondents were mostly male, experienced in their position, and held advanced educational degrees. The demographic information shows that the respondents were predominantly male (94.7%), with the majority reporting

ages between 36 and 55 years (67.3%), and the total group averaged 45.1 years of age. The Iowa Agricultural Agents responding averaged 14.7 years of employment with Cooperative Extension, although almost half (49.5%) indicated having less than 10 years of experience in Cooperative Extension. The data also revealed a highly educated group, as a majority (82.1%) reported attainment of advanced degrees, with 71 (74.7%) having a Master's Degree and 7 (7.4%) a Doctoral Degree.

The distribution of respondents by ISU Extension administrative areas was fairly even when compared to the number of counties in the administrative areas. A majority (76.8%) of the respondents were County Extension Agriculturists, and the balance were Extension Area Specialists with agriculture responsibilities. All positions are considered field staff who work directly with clients in their respective counties or areas, and are distributed throughout Iowa. Of the Iowa Agricultural Extension Agents responding, just over half (52.6%) reported having attended an educational event pertaining to biotechnology, and a majority (87.4%) indicated awareness of the "Office of Biotechnology" on the ISU campus. The respondents indicated awareness of biotechnology, and many are seeking information and training pertaining to biotechnology. One could conclude from these findings that the respondents represent an educated and experienced educational source for agricultural education to people throughout Iowa.

Perceived Training Needs of Respondents in Biotechnology

One of the objectives for this study was to determine the extent of training needs as perceived by Iowa Agricultural Extension Agents

regarding various topic areas in biotechnology. Of the 23 topics relating to biotechnology in which respondents were asked to indicate their perceived level of agreement on training needs, 18 had a mean value above 3.50, indicating their agreement with a need for training in these topic areas. Only five topics were rated between 3.00 and 3.50 (neutral), and the respondents did not rate any item less than 3.00; thus, there was no disagreement with the need for training in each of the topics associated with biotechnology used in this questionnaire.

Seven topics received a mean score above 4.00 (agree), and the highest mean rating was the topic "disease and pest resistant crop varieties," followed closely by other topics relating to crops and livestock, and an item pertaining to economic implications of biotechnology. This finding may be due to the importance placed on crop and livestock production by the respondents, and perhaps to the perceived benefits of these innovations to agriculture. Additionally, these findings may be due to the perceived practicability and applicability of these innovations suggested by the topical areas that were scored high by the respondents. The lowest rated topic was "tissue culture," followed closely by four other topics associated with genetic engineering. Perhaps this finding can be explained by the respondents viewing these items as research topics, but not be as likely to deal with them at the adoption phase of the educational process.

Utilizing a one-way analysis of variance procedure, several significant statistical differences existed between the respondents' perceived need for training regarding topical items in biotechnology when

grouped by different demographic characteristics. The demographic characteristic "age" showed several significant differences between age groups and four topic areas. Of the four items, three deal with economics, policy, and social implications of biotechnology, with an older age group rating these topics significantly higher than a younger age group. Perhaps this finding may be due to older respondents perceiving that biotechnology will have a greater impact on society than younger respondents. The characteristic "educational level" indicated that respondents with Bachelor and Master Degrees rated the topic "disease resistance in livestock" significantly higher. The "administrative area" demographic revealed significant differences between groups in their ratings on three topics. This finding may be due to differences in perceived practicability or applicability of the topic to their local area. The characteristic "employed position in Extension" indicated that respondents who were County Agriculturists rated four topics significantly higher than Area Agriculture Specialists. This finding may be due to the perceived importance of the topics to County Agriculturists to their local area and their perceived benefits to crop and livestock production.

One can conclude from the findings in this section that biotechnology is an important topic to the respondents, and that there is a strong need and desire for training in most of the topic areas in biotechnology as rated by the respondents. The respondents' mean scores for the topics could be used to help target areas in biotechnology for the development of training programs for Iowa Agricultural Extension Agents.

Perceived Informational Needs of Respondents in Biotechnology

Another objective of this study was to determine the degree of importance relating to informational material needed by Iowa Agricultural Extension Agents regarding various topical areas in biotechnology. Of the 23 topics relating to biotechnology in which respondents were asked to indicate their perceived level of agreement with informational material needs, 19 had a mean score rating above 3.50, indicating their agreement with a need for informational material in these topic areas. Only four topics were rated between 3.00 and 3.49 (neutral) and the respondents did not rate any items below 3.00; thus, there was no disagreement with the need for informational material in each of the topics associated with biotechnology used in this questionnaire.

Eight topics received a mean score above 4.00 (agree), and the highest rated topic was "disease and pest resistant crop varieties," followed by six topics relating to crop and livestock, and an item pertaining to economic implications of biotechnology. These findings are very similar to the topics rated highly for training needs discussed in the previous section. Obviously the respondents felt a need for informational materials in the same topic areas that they perceived a need for training. This finding may again be due to the importance placed on crop and livestock production by the respondents, and perhaps to the perceived benefits of these innovations to agriculture. Again, these findings may be due to the perceived practicability and applicability of these innovations suggested by the topical areas that were scored high by the respondents. The lowest rated topic was "gene insertion," followed

closely by three other topics associated with genetic engineering. This finding may be due to the respondents' questioning the likelihood of utilizing this information at the application level for biotechnology innovations.

A one-way analysis of variance procedure found several significant statistical differences between the respondents' perceived need for informational material regarding topical items in biotechnology when grouped by different demographic characteristics. The characteristic "age" indicated that those between ages 36 and 45 years old rated their need for informational material in four topics significantly lower than did those in the other age groups. This finding is consistent with the findings in the training section discussed in the preceding section. The characteristic "educational level" indicated that respondents with a Doctoral Degree rated "using PST in pork production," "using BST in dairy," and "disease resistance in livestock" significantly lower than did the other two groups. This may be due to the other two groups' perception as to importance and/or applicability of these topics on the producer level.

A conclusion that could be made from this section would be that respondents again feel that biotechnology is an important topic and have indicated a need for instructional materials for most of the topical areas identified on the questionnaire. The respondents' mean scores of the topics could be used to help target areas in biotechnology for the development of informational materials.

Perceived Level of Agreement to Statements about Biotechnology

The identification of perceptions held by Iowa Agricultural Extension Agents regarding bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education to the agricultural and public sector was another objective of this study. The respondents were asked to react to five statements pertaining to bioethics, and the statement "consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and the ethics of the 'end-product'" received a mean rating of 4.20 (somewhat agree). As a group, the respondents agreed with the statement "using biotechnology to improve agricultural crops and livestock is moral and ethical," having a mean score of 4.17 (somewhat agree). Agreement with these two statements suggests that the respondents perceive biotechnology use as ethical, but feel consumers will play a role and possibly influence adoption of new innovations produced by biotechnology. The respondents somewhat disagreed (2.07) with the statement "advances made with biotechnology in genetic engineering will have no effect or implications towards human genetic engineering." This finding suggests that the respondents perceived that biotechnology will have implications to human applications.

The respondents were asked to react to twelve statements pertaining to biotechnology's potential impact on agriculture, and the statement "biotechnology will produce plant varieties and livestock species that are more resistant to disease and pests" received the highest mean value of 4.06 (somewhat agree). The next six statements were rated between 2.89

and 3.66. The respondents somewhat disagreed with three statements, including "advances made with biotechnology will probably benefit persons with middle-sized and small farm operations more than persons with large farms," which received the lowest rating at 1.98 (somewhat disagree) and "advances in biotechnology will probably benefit diversified farms more than specialized farm operations," which received a 2.04 rating. Disagreement with these two statements suggests the respondents perceive that advances in biotechnology will probably benefit persons involved with larger, more specialized farm operations than those with smaller, more diversified farm operations.

Respondents were asked to react to statements pertaining to Extension's role in biotechnology education, and all three statements received ratings over 4.00 (somewhat agree). A conclusion that can be drawn from the respondents' agreement to these statements is that as a group, the respondents felt Extension should be very involved with biotechnology education to the general public as well as the agricultural sector, and that applied research should be conducted at on-farm sites throughout Iowa.

A one-way analysis of variance procedure found significant statistical differences between the respondents' perceived agreement to statements regarding biotechnology when grouped by different demographic characteristics. The characteristic "age" indicated that respondents between ages 56 to 65 rated two statements significantly different. The characteristic "educational level" indicated that respondents with a Doctoral Degree showed more disagreement with the statement "biotechnology

will lead farmers to become more dependent on large corporations for many of their inputs, such as seed, growth hormones, and feed additives" than those with a Master's Degree. The characteristic "employed position in extension" indicated respondents who were County Agriculturists rated the statement "biotechnology will produce biological controls that are reliable and economical" significantly lower than Extension Area Agriculture Specialists, and rated the statement "consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality" higher than Extension Area Agriculture Specialists.

An overall concluding statement to summarize this section was the respondents as a group felt biotechnology is ethical and has the potential to impact agriculture in various ways as indicated by the way they reacted to various statements about biotechnology. The findings also suggest that the respondents felt consumer perceptions may influence adoption of innovations produced from biotechnology. Finally, it can be concluded from the findings that respondents perceived that advances in biotechnology will probably benefit persons involved with larger, more specialized farm operations than those with smaller, more diversified farm operations.

Comments Made by Respondents

An analysis of the comments made by respondents indicated that, as a group, they view biotechnology as an important topic and Extension should be involved with the educational aspect of biotechnology. Several respondents indicated the need for training and informational materials to

educate themselves and others about biotechnology. Several comments indicated that ISU Extension should provide leadership in biotechnology. Many cited a lack of time available to spend on biotechnology and question how biotechnology research and education will fit in the new Iowa State University reorganization structure.

Educational Implications of the Findings of the Study

The findings of this study clearly indicate that biotechnology is an important topic to the Iowa Agricultural Extension Agents participating in the study. The findings also implied a perceived need for training and informational materials for most of the selected topics pertaining to biotechnology used in the questionnaire. Furthermore, the mean scores for the topic areas in the training and informational sections could be used to target areas in biotechnology for the development of in-service training programs for Agricultural Extension Agents and the development of informational materials for the respondents and other interested in biotechnology. The respondents implied that training and informational materials were important to educate not only agricultural clients, but also the general public. A comment made by a respondent perhaps sums up this point: "All the good things in the world will fail if public perception is negative. We must instill confidence that the technology is safe."

The findings also implied the respondents felt biotechnology will impact production agriculture. One respondent commented, "We need to help producers assess these new technologies and how they may fit into their production systems," and another stated, "Extension field staff should

become informed and comfortable with subject matter and issues so they can give leadership to disseminating facts and information to educate the clientele." The topics that were rated with the highest degree of agreement regarding training needs, informational material needs, and potential impact on agriculture seemed to be topics or innovations produced by biotechnology that related to crop and livestock production and appeared to have practicability and applicability to these enterprises. Further assessment of the needs of clientele as related to biotechnology will need to be conducted to plan appropriate educational programs.

In conclusion, it is imperative that Iowa Agricultural Extension Agents receive training and informational materials pertaining to biotechnology. The study has given evidence that the Agricultural Extension Agents are well educated, experienced as educators, and are aware of important topics to agriculture, and serve as a valuable resource for agricultural education in Iowa.

CHAPTER VI. SUMMARY, CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to identify perceptions held by Iowa Agricultural Extension agents regarding training and informational needs in biotechnology, and to identify perceptions held regarding bioethics, biotechnology's potential impact on agriculture, and Extension's role in biotechnology education. This chapter is organized under the following sub-headings: (1) Summary; (2) Findings; (3) Conclusions; (4) Recommendations from the Study; and (5) Recommendations for Further Research.

Summary

The study was descriptive in nature, utilizing a questionnaire focusing on the following objectives:

1. To identify the level of importance of agricultural biotechnology as perceived by Iowa Agricultural Extension Agents.
2. To determine the extent of training as perceived by Iowa Agricultural Extension Agents regarding various topical areas in biotechnology.
3. To determine the degree of importance relating to the need for informational materials regarding various topical areas in biotechnology as perceived by Iowa Agricultural Extension Agents.
4. To identify perceptions held by Iowa Agricultural Extension Agents in regard to bioethics, biotechnology's potential

impact to agriculture, and Extension's role in biotechnology education.

5. To compare perceived differences existing in Iowa Agricultural Extension Agents regarding biotechnology according to various demographic factors.

The accessible population consisted of the 120 Iowa State University Extension field staff with agricultural responsibilities. On March 1, 1992, questionnaires were sent out to 31 ISU Extension Area Specialists with agricultural responsibilities and to 89 County Extension Agriculturists. The initial mailing resulted in the completion and return of 75 questionnaires. A follow-up message on "Exnet," ISU's communication system to outlying centers, resulted in the return of 29 more questionnaires for a total of 104, in which 95 were in a usable form for processing. The Cronbach alpha procedure to test reliability for the first two sections of the instrument determined a reliability coefficient of .9022.

Data were statistically analyzed using the Statistical Package for the Social Sciences (SPSS). Means, standard deviations, frequencies, t-tests, and analysis of the variance were used in the study.

Findings

The following findings and conclusions resulted from analysis of the data:

1. Most of the respondents were male (94.7%), with a majority (76.8%) reporting ages between 36 and 55 years old. The

respondents averaged 14.7 years of experience in Cooperative Extension.

2. The majority (82.1%) hold an advanced degree, with 74.7 percent having a Master's Degree and 7 percent a Doctoral Degree. County Extension Agriculturists made up a majority of the group (76.8%), with the balance Area Extension Agriculture Specialists.

3. The five topical areas regarding training needs in biotechnology which received the highest mean scores were: (1) disease and pest resistant crop varieties; (2) herbicide resistant crop varieties; (3) economic implications of biotechnology; (4) disease resistance in livestock; and (5) new crop varieties.

4. The five topical areas regarding informational needs in biotechnology which received the highest mean scores were: (1) disease and pest resistant crop varieties; (2) biological control of pests; (3) herbicide resistant crop varieties; (4) new crop varieties; and (5) new uses for crop and livestock products.

5. The three statements pertaining to biotechnology with the highest mean scores in their sections were: (1) consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the "end-product"; (2) biotechnology will produce plant varieties and livestock

species that are more resistant to disease and pests; and (3) Extension should be very involved with biotechnology in regard to applied research, technology transfer, and innovation-adoption.

Conclusions

1. The findings provide evidence that the respondents felt biotechnology to be an important topic in Extension.
2. The findings verify there is a need for training and informational material pertaining to biotechnology for Iowa Agricultural Extension Agents.
3. The topic areas received similar ratings for both training and informational needs.
4. The respondents as a group viewed biotechnology as an important topic and that ISU Extension should be involved with the educational aspect of biotechnology.

Recommendations from the Study

Based upon the findings of this study, the following recommendations were made:

1. In-service training should be planned for ISU Extension field staff targeting topical areas in biotechnology rated highly in this study.
2. Informational materials should be developed by ISU to inform and educate staff about biotechnology, targeting those areas identified in this study as important to the respondents.

3. Publications and other informational materials should be developed and distributed by ISU Extension to help educate the agricultural and public sectors about biotechnology.
4. The results of this study should be shared with ISU Extension's program leader for Agriculture and Natural Resources and others responsible for planning in-service training for extension personnel.
5. Educational programs focusing on innovations produced from biotechnology that relate to crop and livestock production be planned and delivered to Iowa Agricultural Extension Agents and other agricultural educators.
6. Biotechnology topics inserted into ISU Extension's program plan of work materials that are used by county and area program planning committees.

Recommendations for Further Research

1. A similar study involving farmers should be conducted to determine their perceptions regarding training and informational needs in biotechnology.
2. This study should be replicated with other Agricultural Extension Agents in other states and the results compared with the findings of this study.
3. This study should be repeated to determine if training and informational needs of extension agents are being met and to determine if perceptions have changed.

4. A follow-up survey should be conducted with the respondents using the topics identified in this study that were rated high and target more precise needs within those topical areas.

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ACKNOWLEDGMENTS

My interest in agricultural extension education and biotechnology has strengthened as a result of this study. I am convinced that ISU Extension will play a lead role in biotechnology education, as it will other issues that have the potential to impact agriculture.

I would like to express my thanks to my major professor, Dr. Robert A .Martin, for his professional guidance, commitment to quality, sense of humor, and words of encouragement throughout my Master's Degree program.

Appreciation is also expressed to Dr. Wade Miller and Dr. Joe Sebranek for serving on my graduate committee.

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APPENDIX A. QUESTIONNAIRE

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY
Cooperative Extension

103

Mahaska County
113 A Avenue West
Oskaloosa, Iowa 52577
515 673-5841

March 2, 1992

Dear Agricultural Extension Professional:

Biotechnology has become a critical issue in agriculture. The perceptions of Extension Agriculturists and Extension Specialists are important in determining informational needs and identifying priority areas for training in the field of biotechnology.

We need your help! The purpose of this study is to identify perceptions regarding various aspects of agricultural biotechnology and to identify training and information needs of extension field staff. This information is essential in determining what type of information should be made available to extension field staff as you provide assistance to Iowa producers and agribusiness personnel. Additionally, your responses will help prioritize topics for future in-service training programs for extension field staff.

Please complete the enclosed questionnaire. Fill in all responses. This should take no more than 20 minutes of your time. The information will be held in strict confidence. Individual responses will not be published. We are interested only in group data. Coding of the survey form is a means of contacting non-respondents. Upon receipt of the survey forms all code numbers will be removed. All instruments will be destroyed following analysis of the group data. The data will be used to complete a Masters degree and to help develop agricultural biotechnology related training programs and informational materials. Participation is voluntary. If you do not wish to participate, please return the unused questionnaire.

We hope you will take a few minutes to assist us by completing and returning the questionnaire by March 16, 1992. A self-addressed stamped envelope is enclosed for your convenience. We appreciate your cooperation. If any questions arise regarding the completion of the survey form, please feel free to contact the undersigned individuals.

Sincerely,

E Craig Williams
E. Craig Williams
Extension Agriculturist

Robert A. Martin
Robert A. Martin
Associate Professor

Section I NEED FOR TRAINING AND INFORMATIONAL MATERIALS.

INSTRUCTIONS: In column "A" please circle the number which best reflects your personal need for training in regards to each of the topics relating to agricultural technology. In column "B" please circle the number which best reflects your personal opinion regarding the need for additional informational materials on each topic. Please circle only one response in each of the columns for each topical area.

1=(S)trongly (D)isagree 2=(D)isagree 3=(N)uetral 4=(A)gree 5=(S)trongly (A)gree

(A) Need for Training	*Topic*	*The Degree You Feel Informational Material is Needed.*
SD D N A SA		*SD D N A SA*
1 2 3 4 5	*Genetic Engineering*	*1 2 3 4 5*
1 2 3 4 5	*Recombinant DNA*	*1 2 3 4 5*
1 2 3 4 5	*Gene Insertion*	*1 2 3 4 5*
1 2 3 4 5	*Cloning*	*1 2 3 4 5*
1 2 3 4 5	*Tissue Culture*	*1 2 3 4 5*
1 2 3 4 5	*Using porcine Somatotropin(PST) pork production*	*1 2 3 4 5*
1 2 3 4 5	*Using Bovine Somatotropin(BST) in Dairy*	*1 2 3 4 5*
1 2 3 4 5	*Growth regulators*	*1 2 3 4 5*
1 2 3 4 5	*Diagnostic Kits Using Biotechnolgy*	*1 2 3 4 5*
1 2 3 4 5	*New Crop Varieties*	*1 2 3 4 5*
1 2 3 4 5	*Herbicide Resistant Crop Varieties*	*1 2 3 4 5*
1 2 3 4 5	*Disease and Pest Resistant Crop Varieties*	*1 2 3 4 5*
1 2 3 4 5	*Disease Resistance in Livestock*	*1 2 3 4 5*
1 2 3 4 5	*Corn varieties that Fix own Nitrogen*	*1 2 3 4 5*
1 2 3 4 5	*Biological Control of Pests*	*1 2 3 4 5*
1 2 3 4 5	*Enviornmental Impacts of Biotechnology*	*1 2 3 4 5*
1 2 3 4 5	*New uses for Crop and Livestock Products*	*1 2 3 4 5*
1 2 3 4 5	*New uses for Agricultural By-products*	*1 2 3 4 5*
1 2 3 4 5	*Risk Assessment of Biotechnology*	*1 2 3 4 5*
1 2 3 4 5	*Economic Implications of Biotechnology*	*1 2 3 4 5*
1 2 3 4 5	*Policy Implications of Biotechnology*	*1 2 3 4 5*
1 2 3 4 5	*Social Implications of Biotechnology*	*1 2 3 4 5*
1 2 3 4 5	*Bioethics*	*1 2 3 4 5*

SECTION 2

PERCEPTIONS REGARDING AGRICULTURAL BIOTECHNOLOGY.

Directions: Please indicate your degree of agreement with each of the following statements by encircling the appropriate number against each statement. Please encircle "1" if you strongly disagree; encircle "5" if you strongly agree.

Please use the folowing scale to express your agreement.

1 - Strongly Disagree
2 - Disagree
3 - Nuetral
4 - Agree
5 - Strongly Agree

PERCEPTIONS OF AGRICULTURAL BIOTECHNOLOGY ISSUES AS RELATED TO BIOETHICS, IMPACT TO U.S. AGRICULTURE, AND EXTENSION'S ROLE.

1 2 3 4 5 *1. Using biotechnology to improve agricultural crops and livestock production is moral and ethical.*

1 2 3 4 5 *2. Advances made with biotechnology in genetic engineering will have no effect or have implications towards human genetic engineering.*

1 2 3 4 5 *3. Risk assessment should be a primary component of agricultural biotechnology research.*

1 2 3 4 5 *4. Consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality.*

1 2 3 4 5 *5. Consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regards to quality, saftey, and ethics of the "end-product".*

1 2 3 4 5 *6. Advances in biotechnology will probably benefit persons with middle sized and small farm operations more than persons with large farms.*

1 2 3 4 5 *7. Advances in biotechnology will probably benefit diversified farms more than specialized farm operations.*

1 2 3 4 5 *8. Biotechnology will produce plant varieties and livestock species that are more resistant to disease and pests.*

1 2 3 4 5 *9. Biotechnology will cause farmers to become more dependent upon agricultural chemicals.*

1 2 3 4 5 *10. Biotechnology will produce biological controls for pests that are reliable and economical.*

1 2 3 4 5 *11. Biotechnology will improve the economic stability of farm families and bring improved levels of living.*

1 2 3 4 5 *12. Biotechnology will lead farmers to become more dependent upon large corporations for many of their inputs, such as seeds, growth hormones, and feed additives.*

1 2 3 4 5 *13. Biotechnology will help solve the problem of farm surpluses by finding new uses for crops, livestock, and their by-products.*

1 2 3 4 5 *14. Economic gains will be realized from the timely adoption of growth promotents (PST; BST).*

1 2 3 4 5 *15. Biotechnology will assist the development of sustainable agriculture.*

1 2 3 4 5 *16. Biotechnology will cause over production and surpluses of agricultural commodities.*

1 2 3 4 5 *17. Biotechnology will have an adverse effect on the environment.*

1 2 3 4 5 *18. Extension should be very involved with biotechnology in regards to applied research, technology transfer, and innovation-adoption.*

1 2 3 4 5 *19. Extension state and field specialists should be actively involved in applied research at on-farm sites throughout the state.*

1 2 3 4 5 *20. Extension will play a critical role in educating the general public and addressing "public perceptions" regarding biotechnology in agriculture.*

Section 3: DEMOGRAPHIC INFORMATION.

Instructions: Please circle, or place in the space provided, the appropriate response.

A. Your gender is:
1. Female
2. Male

B. Your age in years is: _____

C. Number of years employed by Extension: _____

D. Your educational level is:
1. Bachelors
2. Masters
3. Doctoral

E. Extension Administrative Area in which you work:
1. Southeast
2. Southwest
3. Northeast
4. Northwest
5. North Central
6. Central
7. East Central

F. What level are you employed with Extension?

1. County
2. Area (subject matter:_____)
3. Special Funded (Model Farms, Live. Initative, etc)

G. Have you attended any workshops, conferences, or coursework pertaining to biotechnologies in agriculture? If yes, indicate the title, and when and where it was held.

1. Yes _____
_____

2. No

H. Are you aware that there is an "Office of Biotechnolgy" on the ISU campus? (yes or no)

I. Comments on the role of Extension providing leadership in the field of agricultural biotechnology; or general comments regarding this questionnaire:

_____
_____
_____

THANK YOU FOR YOUR COOPERATION!

PLEASE RETURN BY MARCH 16, 1992 TO:
CRAIG WILLIAMS, EXTENSION AGRICULTURIST
Mahaska County Extension Service
113 A Av W, Oskaloosa, IA 52577

APPENDIX B. HUMAN SUBJECTS APPROVAL FORM

Checklist for Attachments and Time Schedule

The following are attached (please check): "N. A."

12. ☐ Letter or written statement to subjects indicating clearly:
    a) purpose of the research
    b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
    c) an estimate of time needed for participation in the research and the place
    d) if applicable, location of the research activity
    e) how you will ensure confidentiality
    f) in a longitudinal study, note when and how you will contact subjects later
    g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. ☐ Consent form (if applicable)

14. ☐ Letter of approval for research from cooperating organizations or institutions (if applicable)

15. ☐ Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact	Last Contact
March 2, 1992	March 20, 1992
Month / Day / Year	Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

March 30, 1992
Month / Day / Year

18. Signature of Departmental Executive Officer | Date | Department or Administrative Unit

David K. [illegible] | 2/19/92 | AGEDS Dept.

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith	2/27/92	P M Keith
Name of Committee Chairperson	Date	Signature of Committee Chairperson

APPENDIX C. CORRESPONDENCE

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY
Cooperative Extension

Mahaska County
113 A Avenue West
Oskaloosa, Iowa 52577
515 673-5841

March 11, 1992

TO: County Extension Agriculturists
Area Ag. Specialists

FROM: Craig Williams
Mahaska County Extension Agriculturist

RE: Biotechnology Survey

Thanks for taking a few minutes to complete and return my survey regarding "Agricultural Biotechnologies"!

Seventy-five surveys have been received as of 3/9/92. If you have not completed and returned your survey, I would appreciate your doing so soon, as my target date is March 16th. THANKS!

APPENDIX D. TABLES

Table D-1. Means and standard deviations of level of agreement regarding training needs of Agricultural Extension Agents towards various topical areas of biotechnology (n=95)

Topics	Mean[a]	S.D.
Genetic Engineering	3.46	0.94
Recombinant DNA	3.22	0.98
Gene Insertion	3.24	0.97
Cloning	3.26	0.97
Tissue Culture	3.21	1.03
Using Porcine Somatotropin (PST) in Pork Production	3.96	1.04
Using Bovine Somatotropin (BST) in Dairy	3.70	1.17
Growth Regulators	3.97	0.86
Diagnostic Kits Using Biotechnology	3.73	0.84
New Crop Varieties	4.03	0.99
Herbicide Resistant Crop Varieties	4.16	0.93
Disease and Pest Resistant Crop Varieties	4.22	0.90
Disease Resistance in Livestock	4.05	0.90
Corn Varieties that Fix Own Nitrogen	3.90	1.00
Biological Control of Pests	4.02	0.94
Environmental Impacts of Biotechnology	3.95	0.87
New Uses for Crop and Livestock Products	4.02	0.82
New Uses for Agricultural By-Products	3.92	0.84
Risk Assessment of Biotechnology	3.90	0.86
Economic Implications of Biotechnology	4.11	0.82
Policy Implications of Biotechnology	3.72	0.92
Social Implications of Biotechnology	3.81	0.96
Bioethics	3.72	0.93

[a]1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree= 5 = strongly agree.

Table D-2. Means and standard deviations of level of agreement regarding informational material needs of Agricultural Extension Agents towards various topical areas of biotechnology (n=95)

Topics	Mean[a]	S.D.
Genetic Engineering	3.63	1.02
Recombinant DNA	3.34	0.98
Gene Insertion	3.29	1.03
Cloning	3.45	0.94
Tissue Culture	3.32	1.00
Using Porcine Somatotropin (PST) in Pork Production	4.16	0.93
Using Bovine Somatotropin (BST) in Dairy	3.98	0.99
Growth Regulators	4.10	0.85
Diagnostic Kits Using Biotechnology	3.88	0.92
New Crop Varieties	4.27	0.91
Herbicide Resistant Crop Varieties	4.30	0.81
Disease and Pest Resistant Crop Varieties	4.33	0.82
Disease Resistance in Livestock	4.16	0.79
Corn Varieties that Fix Own Nitrogen	4.04	0.97
Biological Control of Pests	4.31	0.86
Environmental Impacts of Biotechnology	4.11	0.86
New Uses for Crop and Livestock Products	4.23	0.84
New Uses for Agricultural By-Products	4.08	0.90
Risk Assessment of Biotechnology	4.04	0.89
Economic Implications of Biotechnology	4.17	0.82
Policy Implications of Biotechnology	3.84	0.96
Social Implications of Biotechnology	3.87	0.90
Bioethics	3.84	0.94

[a]1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree= 5 = strongly agree.

Table D-3. Means and standard deviations of level of agreement regarding Agricultural Extension Agents' perceptions to statements pertaining to bioethics (n=95)

Topics	Mean[a]	S.D.
Using biotechnology to improve agricultural crops and livestock production is moral and ethical.	4.16	0.95
Advances made with biotechnology in genetic engineering will have no effect or have implications towards human genetic engineering.	2.07	1.04
Risk assessment should be a primary component of agricultural biotechnology research.	4.00	1.10
Consumers will readily accept agricultural food products if assured the products are safe and are the same or better in quality.	3.10	1.14
Consumers will greatly influence the adoption of new innovations produced by biotechnology based on their perceptions in regard to quality, safety, and ethics of the "end-product."	4.20	0.97

[a]1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree= 5 = strongly agree.

Table D-4. Means and standard deviations of level of agreement regarding Agricultural Extension Agents' perceptions to statements pertaining to biotechnology's potential impact to agriculture (n=95)

Topics	Mean[a]	S.D.
Advances in biotechnology will probably benefit persons with middle-sized and small farm operations more than persons with large farms.	1.98	0.85
Advances in biotechnology will probably benefit diversified farms more than specialized farm operations.	2.04	0.91
Biotechnology will produce plant varieties and livestock species that are more resistant to disease and pests.	4.06	0.86
Biotechnology will cause farmers to become more dependent upon agricultural chemicals.	2.28	0.89
Biotechnology will produce biological controls for pests that are reliable and economical.	3.55	0.79
Biotechnology will improve the economic stability of farm families and bring improved levels of living.	2.89	0.81
Biotechnology will lead farmers to become more dependent upon large corporations for many of their inputs, such as seeds, growth hormones, and feed additives.	3.65	0.93
Biotechnology will help solve the problem of farm surpluses by finding new uses for crops, livestock, and their by-products.	3.04	0.95
Economic gains will be realized from the timely adoption of growth promotents (PST;BST).	3.66	0.88
Biotechnology will assist the development of sustainable agriculture.	3.60	0.89

[a]1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree= 5 = strongly agree.

Table D-4. (Continued)

Topics	Mean[a]	S.D.
Biotechnology will cause over-production and surpluses of agricultural commodities.	3.14	0.87
Biotechnology will have an adverse effect on the environment.	2.29	0.92

Table D-5. Means and standard deviations of level of agreement regarding Agricultural Extension Agents' perceptions to statements pertaining to Extension's role in education concerning biotechnology (n=95)

Topics	Mean[a]	S.D.
Extension should be very involved with biotechnology in regard to applied research, technology transfer, and innovation-adoption.	4.126	1.17
Extension state and field specialists should be actively involved in applied research at on-farm sites throughout the state.	4.074	1.12
Extension will play a critical role in educating the general public and addressing "public perceptions" regarding biotechnology in agriculture.	4.021	1.14

[a]1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree= 5 = strongly agree.