A national study to determine the role of biosciences / biotechnology in agricultural education as perceived by vocational agriculture instructors

by

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CHAPTER I. INTRODUCTION

> Agriculture, the nation's largest industry, is changing. It is changing from an industry that is by tradition production oriented to one that requires more professionals in marketing, management, science, education,and communications. Today's agriculturalists are seeking new and better methods of achieving higher agricultural production, while striving to meet consumer demands of what is produced, as well as how it is managed, processed, and marketed (Duval, 1988, p. 18).

Problem

One of the new methods of agricultural production is the application of biotechnology in agriculture. Biotechnology is a buzz word commonly heard in conversation today, but seldom understood beyond the realm of science. Yet biotechnology is being called agriculture's third wave, comparing it to machines replacing human labor and chemicals being introduced into agricultural production (Lasley, 1987). Biotechnology with all its inherent complexities, mysteries, problems, and challenges, promises to revolutionize farming and agriculture. In addition, it is expected to become the major source of innovation for agriculture by the early 21st century. One recent survey of knowledgeable representatives of the farming, industrial, government, and academic sectors projected biotechnology to provide forty percent of the innovations for crop production in the year 2005 while traditional technologies were expected to provide only thirty percent (Hardy, 1985). Doyle (1985, p. 21) stated that with biotechnology the scientific sanction in agriculture has gone one step further. He further emphasized the significance of biotechnology in future agricultural endeavors in the following statement:

> Biotechnology will shift the centers of food production from the traditional resources of land, water, and farmer to the remote reaches of the electron microscope and the tiny world of molecular biology. It holds beneficial possibilities for agriculture, the

> environment and food production. With speed and accuracy, these technologies promise to remedy all manner of agricultural problems confronting every society attempting to feed itself. For example, livestock can be engineered to produce more and better quality meat, milk, and eggs on less feed.

In addition to increased production, the biotechnology also lowers the cost of production for farmers according to Hardy (1985, p. 311). He further added:

> Agriculture must have lower cost of production, and in part, replace unprofitable commodity gains with higher value in-use specialty crops which is possible with biotechnology.

According to Marshall (1987, p. 10), biotechnology has certain specific advantages:

1. To use biotechnology to reduce input costs in order to reduce subsidies and increase exports.
2. To develop inexpensive biotechnologies to match the inexpensive products of agriculture.
3. To maintain our natural resources for future generations.

Because of these advantages, the field of biotechnology is gaining momentum in the area of agricultural education. The importance of biotechnology to vocational agricultural education was explained by Martin (1988, p. 1):

> Biotechnology is producing new high technology industries that are in themselves providing new jobs and producing new goods and services. Because of the emergence of the biotechnology based industries, the need for developing an awareness of the scientific foundation of the agricultural industry is becoming one of the major issues of our time. The infusion of biotechnology into high school vocational agriculture programs as well as the emphasis of all science pertinent to agriculture will enhance career opportunities for those persons seeking an education in agriculture.

Zurbrick (1989, p. 4) supported the above statement:

> We have the talents and the mandate to create another agricultural education at the secondary level. Programs have waiting lists of students desiring to enroll. Could these programs be a prototype of an additional program delivery system for agricultural education at the secondary level? Perhaps the agricultural education profession's contribution to agricultural literacy at the secondary level could be built upon agricultural science. We should not assume that the agricultural education profession can nor should assume responsibility for all aspects of agricultural literacy. Perhaps our contribution to the movement should be developing an understanding of biotechnology in agriculture by students at the secondary level.

Luft and Peterson (1989) illustrated a case where the program advisory committee in Lake Area Vocational Center in Devils Lake, North Dakota, emphasized the revitalization of vocational agriculture program in order to solve problems such as declining enrollments, lack of student interest, and an inability to meet minimum class sizes as required by the State Board of Vocational Education. Hence, the committee prioritized the development of agriscience and technology for effective program revitalization. The Iowa Technical Committee on Biotechnology recognized that educational programs must move from a narrow, production agriculture emphasis to a contemporary curriculum that prepares students for diverse careers in the agricultural industry (Martin, 1987). An example of occupational opportunities for students of vocational agriculture was provided by the Committee on Agricultural Education in Secondary Schools (1988, p. 4):

> Soon applications of biotechnology, including disease monitoring kits and other assay methods based on monoclonal antibodies especially to detect pregnancy in livestock, will be more accessible. Students will need to understand how these assay systems work and the conditions under which they are accurate. This requires learning the fundamental principles of genetics.

According to Stansbury and Coulter (1986), agriculture affords dynamic and exciting career opportunities with domestic and international dimensions for students of vocational agriculture. A study conducted by the United States Department of Agriculture during 1986 revealed that of the 49,000 annual employment opportunities for college graduates in the food and agricultural sciences, 28 percent of the career opportunities are for scientists, engineers, and technicians.

It is evident from the above statements that students of agriculture must learn the sciences related to agriculture. Biosciences such as plant science, animal science, genetics, microbiology, soil science, and food science provide the foundation for the growth and development of the industry in agriculture.

Need for the Study

The application of biotechnology must be shared with students of agriculture in order to educate them regarding the occupations available in the field. The study of the biosciences would pave the way for thorough preparation of students by laying down a strong foundation in the principles and concepts of the biosciences over which a super structure of agricultural biotechnology can be built in the years to come. It would be very difficult for students to understand the application of biotechnology unless they were thoroughly prepared in the fundamentals. For instance, increasing the production of animals through the use of genetics cannot be understood unless students have some basic knowledge about cell functions and make-up in animals.

Keeping these developments in mind, the Iowa Technical Committee on Biotechnology recommended the concept of infusing more of the basic sciences into the vocational agriculture curriculum in order to prepare students for the highly sophisticated agriculture industry of the future (Martin, 1987). The committee also developed an inventory of bioscience competencies appropriate for the agriculture curriculum. The Committee on Agricultural Education in Secondary Schools (1988, p. 2) established by the National Research Council also supported the recommendations of Iowa Technical Committee on Biotechnology in the following passage:

> New efforts are needed to reform secondary school agriculture programs to better prepare students for agriculture-sector growth industries. An essential step towards achieving this goal is to fully accept the broadened definition of agricultural education recommended by the committee. In some cases, this will require change in abandonment of vocational guidelines. Under vocational agriculture, this definition would include greater diversity of paths, such as scientific research, technology development, management and marketing.

However, one might find it very difficult to proceed further in this direction without an adequate knowledge of what is happening in the field. Although sciences pertinent to agriculture are being taught, we do not know to what extent they are being taught nor do we know the gap between what is being taught and what more should be taught related to the sciences of agriculture. In addition, certain interesting questions raised by Smith (1989, p. 10), supported the purpose to which this study was intended:

> Many educators question what needs to be taught in the sciences related to agriculture. How much science should be taught in vocational agriculture programs? Is biotechnology likely to have an impact that would warrant a specialized curriculum effort? Should information on biotechnology be integrated into all aspects of agriculture curricula? Which existing resource materials can best help teach about biotechnology in agriculture?

Purpose of the Study

An attempt was made to identify perceptions held by teachers of agriculture in the U.S.A. regarding the infusion of the biosciences into the study of agriculture. The study also sought to measure the degree of acceptance which could be expected on the part of the teachers as further efforts are implemented to infuse the biosciences into vocational agriculture programs across the nation. Additionally, the purpose of the study was to lay some groundwork for future research and development of instructional materials in the area of biosciences. The results of this investigation would provide useful information to agricultural educators throughout the United States who are concerned with developing linkages with industry to emphasize the application of science, and others who are concerned with developing instructional materials to incorporate the biosciences into the study of agriculture.

Hence, if vocational agriculture is to keep pace with the present-day demands of the agricultural industry and needs to incorporate competencies related to the biosciences, answers to certain questions must be obtained and be available for educational researchers related to vocational agriculture. The following questions were considered for the study:

1. To what level currently are the biosciences important in vocational agriculture education?
2. To what degree would agriculture instructors increase instruction in the biosciences given selected resources and inservice education?
3. What degree of agreement is expressed among vocational agriculture instructors regarding the role of "biosciences" and "biotechnology" in agricultural education?

4. What perceived differences exist in regard to the infusion of bioscience competencies into the vocational agriculture among the six National Vocational Agriculture Teachers Association regions of the U.S.A.?
5. What perceived differences exist in regard to the infusion of biosciences into vocational agriculture according to selected demographic factors?

The overall purpose of this study was to identify the perceptions held by vocational agriculture instructors in the U.S.A. regarding the infusion of the biosciences into the study of agriculture

Objectives

The specific objectives of this study were:

1. To identify the level of importance of the biosciences as perceived by vocational agriculture instructors in the U.S.A.
2. To determine the degree to which instruction in the biosciences would be increased by vocational agriculture instructors in the U.S.A. given selected instructional materials and inservice education.
3. To determine perceptions held by vocational agriculture instructors regarding teaching the biosciences.
4. To compare the various groups of respondents regarding their perceptions of selected bioscience competencies and demographic factors.

Operational Definitions

Vocational agriculture instructor: A person responsible for teaching and conducting a reimbursable vocational agriculture program in a public high school which were authorized by federal and state legislation including the Smith-Hughes Act of 1917 and subsequent legislation.

Bioscience: Any science whose systematized knowledge and principles are applied to the functions and problems of living organisms.

Biotechnology: Any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses.

National Vocational Agriculture Teachers Association Regions: The six geographical divisions of the National Vocational Agriculture Teachers Association (NVATA), an affiliation of fifty state vocational agriculture teacher associations and these regions are referred to as region I, region II, region III, region IV, region V, and region VI (see Figure 1).

Level of importance of bioscience competencies: The level of specific knowledge and skills in a bioscience area that is perceived to be important by vocational agriculture instructors in secondary schools.

Level of expansion of bioscience competencies: The level to which instruction in specific knowledge and skills in a bioscience area should be expanded in vocational agriculture programs in secondary schools.

Implications to Educational Practice

The study had implications to educational practice and teachers of agricultural education. Understanding the extent to which the bioscience competencies are important and the extent to which these sciences should be expanded in the instructional program provided important information to agricultural educators. As the Committee on Agricultural Education in Secondary Schools (1988) appointed by the

National Research Council found certain changes in the present vocational agriculture curriculum are inevitable, the study of agriculture instructors' perceptions was expected to play a key role in implementing such change. Though a considerable number of educational leaders expressed the need for infusion of the biosciences into the vocational agriculture program, it was thought impossible to proceed further in this direction without knowing what was being taught and how the agriculture teachers in the high schools perceived this change. It was expected that the results of this study would assist educational practitioners in developing instructional materials on the biosciences and also aid in conducting inservice training for agriculture instructors that would in turn help students in acquiring occupations in the diverse agriculture industry.

CHAPTER II. REVIEW OF LITERATURE

The primary purpose of this study was to identify the perceptions held by teachers of vocational agriculture in the U.S.A. regarding the infusion of the biosciences into the study of agriculture. The specific objectives of this research were: (1) To identify the level of importance of the biosciences in vocational agriculture as perceived by agriculture instructors in the U.S.A., (2) To determine the degree to which instruction in the biosciences would be increased by vocational agriculture instructors in the U.S.A. given selected instructional materials and inservice education, (3) To determine perceptions held by vocational agriculture instructors regarding teaching the biosciences, (4) To compare the various groups of respondents regarding their perceptions on selected bioscience competencies and demographic factors.

An in-depth search of the literature was made with the goal of becoming familiar with the research and literature related to this study. Several ERIC searches were conducted using the facilities available at the library of the Iowa State University. Referenced journal articles, books, published papers, and committee reports were reviewed in order to find out specific relationships to this study. It was clearly understood from the review of literature that most of the work related to this study was of a very recent nature.

The study of literature revealed that contributory work was done in determining the significance of the biosciences to modern agriculture and how the bioscience principles are important in the utilization of biotechnology. There had, however, been no known work done to study the perceptions of vocational agriculture instructors regarding the role of the biosciences in agricultural education. The review of literature provided the rationale for this study.

This chapter has been divided into the following sections:

1. Bioscience as a foundation for biotechnology
2. Needs assessment
3. Role of biosciences in developing career opportunities
4. Meeting the needs of vocational agriculture students
5. Science credits for bioscience instruction
6. Role of biosciences in FFA and Supervised Occupational Experience Programs
7. Biosciences and emerging technologies
8. Related studies.

Bioscience as a Foundation for Biotechnology

A clear distinction between the biosciences and biotechnology is essential in order to proceed further into this section. The term bioscience is defined as "any science whose systematized knowledge and principles are applied to the functions and problems of living organisms" (Webster's Dictionary, 1984). Smith (1989) defined biotechnology as the collection of techniques used to influence living things at the cellular level to produce commercial products. According to United States Department of Agriculture, biotechnology is defined as "any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses." The U.S. Department of Agriculture's definition of biotechnology could be rewritten as follows to highlight the biosciences which are "hidden" in each discipline of biotechnology:

"Any technique that uses living organisms (<u>Plant science & Animal science</u>) to make or modify products, to improve plants and animals (<u>Genetics</u>), or develop microorganisms (<u>Microbiology</u>) for specific uses."

The importance of the biosciences and how the study of the biosciences provides the foundation for biotechnology is clearly illustrated by Mayer and McInerney (1984, p. 74) through the following statement:

> Without adequate biological knowledge, we can despoil our planet and hasten our own demise. Without the understanding of the biosciences, we are apt to squander both renewable and non-renewable resources. The study of genetics, one of the important disciplines of biosciences, helps the students to have greater understanding of structure and function of DNA, the basic material for genetic manipulation in plants and animals, in order to apply the concepts into the growing biotechnology. This new biology also promises improvements in nitrogen fixation, photosynthesis, and resistance to pests and pathogens of crop plants. The application of genetic technologies in livestock increases weight gain, increase productivity, and improves resistance to diseases. The study of microbiology, another discipline of the biosciences, provide many opportunities to investigate and apply techniques such as E. Coli with little expense and with the equipment available in most high school laboratories.

Harlander and Garner (1986, p. 36) provided another example on how the knowledge of basic sciences such as fermentation is essential for food processing industries:

> Fermentation is the use of enzymes produced by microorganisms to change an organic compound into other substances such as carbonmonoxide and alcohol. Fermentation of milk, meat and fish, fruits and vegetables, and cereal grains by microorganisms creates products which contribute to the flavor, texture, and keeping quality of food. Further, this process suppresses the growth of disease and spoilage organisms and thereby enhances the nutritional quality of the final product.

The tools of biotechnology that build on a base of understanding derived from the biosciences such as genetics, microbiology, and biochemistry complement the traditional methods of agricultural production (Hess, 1987). Kam (1984) supported this statement by arguing that students need a strong foundation in these basic sciences not only to prepare for broad careers in the field of biotechnology but also to enhance the application of this new biology on their farms. McCormick and Cox (1988) were more or less of the similar view when they expressed that it was no longer educationally sound to teach only the specific facts of agribusiness and renewable natural resources without blending the "why" and "know-how" aspects of the basic sciences. Knowledge of the basic biology of microorganisms such as growth and metabolism of viruses, bacteria, and fungi are essential for identifying naturally occurring control agents (National Academy of Sciences, 1985).

The National Science Board, a commission on pre-college education in mathematics, science and technology believes that basic science and instruction is necessary to produce the following outcomes, according to Buriak (1989, p. 12):

* Ability to formulate questions about nature and find answer from observation and interpretation of natural phenomena.
* Development of students' capacities for problem solving and critical thinking in all areas of learning.
* Development of particular talents for innovative and creative thinking.
* Awareness of nature and scope of wide variety of science and technology related careers open to students of varying aptitude and interests.
* The basic academic knowledge necessary for advanced study by students who are likely to pursue science professionally.

The following statement by Rao and Pritchard (1984, p. 44) illustrated that the above generic principles could be applied to the biosciences:

> Bioscience principles can be applied to the solving of immediately perceived and identifiable problems arising from pupils' own

observations of a practical situation, which is generally initiated by their experience with plants and animals.

Needs Assessment

The Committee on Agricultural Education in Secondary Schools (1988, p. 3) emphasized the need for a change in the present vocational agriculture program:

> Much of the focus and content of many vocational agriculture programs is outdated. Production agriculture - farming still dominates most programs, although it no longer represents a major proportion of the jobs in the total agricultural industry. Traditional vocational agriculture programs and the students' organization, the FFA, are not meeting the broader needs for agricultural education generated by changes in the food and fiber industries and society as a whole. SOE programs often do not reflect the broad range of opportunities in today's agricultural industry.

An awareness on the infusion of the biosciences into vocational agriculture was created by the Iowa Technical Committee on Biotechnology (1987). Martin (1987) provided the rationale for the need for infusion of the biosciences into agricultural education in secondary schools:

1. Bioscience places increased emphasis on broadening students' knowledge of basic agricultural functions and systems.
2. It directs attention to the need to improve traditional technologies, processing and utilizing agricultural products, and provides specific instruction on the environment, energy, and natural resources.
3. The current developments in the field of biotechnology cannot be understood by the students of vocational agriculture unless the fundamental principles of the biology are taught.
4. It enhances the image of agriculture by portraying to students that agriculture includes many careers that are business oriented.

5. It allows secondary schools to emphasize the new era in agricultural biotechnology and keep up with scientific technology and innovations.

Moore (1987, p. 56) supported the above listing in the following statement:

> Students should come to appreciate that the species providing our food and fiber are part of a vast web of life that functions as an integrated whole. Every species of plant and animal depends not only on its physical environment but on the biological component of the environment as well. All living creatures are part of the same cycles of matter and energy. Thus, education will be incomplete unless students learn what is essential for the lives of our crops, animals, and plants.

According to Williams (1987), major changes are needed in vocational agriculture to reflect the needs of modern agricultural industry especially in the areas of agricultural biotechnology, food processing and distribution of agricultural products. New developments in crop and animal breeding techniques, insect and disease control also need to be addressed (Sutphin, 1985). Moreover, Malpiedi (1989, p. 2) pointed out that the concern for science in the agriculture curriculum has been brought to our attention by three movements:

1. The back to basics emphasis on mathematics and science,

2. The National Study on Agricultural Education in the United State which stated that "the subject matter about agriculture and in agriculture must be broadened", and

3. The rapid pace by which agriculture is changing as a result of technological advances.

She further felt that our efforts to emphasize science concepts and applications in agricultural education often fall on deaf ears or some of our programs have "watered down" the science applications and carry reputations as "crib" courses in the school. The National Commission on Pre-college Education (1983) also reported a need for curricula which utilize the biosciences applied in practical situations to improve learning and stimulate interest of the students. The statements made by Forte (1989, p. 15) would help to understand the significance of when and where scientific principles of agriculture should be taught:

> We need to do a better job of cross referencing the agricultural skills that we do teach with their corresponding science competency and scientific principle. It would make everyone, ourselves, our students, fellow teachers, counsellors, administrators, and parents more aware of the "science in agriculture." We, perhaps, also need some curriculum development and inservice for agricultural teachers to "cue" them into knowing how and when to teach and use corresponding scientific principles.

The significance given to the biosciences could be recognized from the recommendations of the Committee on Agricultural Education in Secondary Schools (1988) established by the National Research Council at the request of the U.S. Secretaries of Agriculture and Education. This committee aimed at assessing the contributions of instruction in agriculture to the maintenance and improvement of agricultural productivity and economic competitiveness. The following are excerpts of its recommendations:

1. Ongoing efforts should be expanded and accelerated to upgrade the scientific and technical content of vocational agriculture courses. The "vocational" label should be avoided to help attract students with diverse interests, including the college bound and those aspiring to professional and scientific careers in agriculture.

2. New curriculum components must be developed and made available to teachers addressing the sciences basic to agriculture, food and natural resources and tools to improve the efficiency of agricultural productivity.

3. Establishment of specialized magnet high schools for the agricultural sciences in major urban and suburban areas should be encouraged.

4. The quality of vocational agriculture programs must be enhanced, in some cases substantially.

5. Exemplary programs in local schools that have broadened the curriculum and improved the attractiveness of agricultural education programs should be identified, studied and emulated.

A study conducted by the National Association of Supervisors of Agricultural Education (1987, p. 1) supported further the need for infusion of the biosciences into agricultural education in the secondary schools:

> The image of the instructional program in vocational agriculture must be changed to reflect a scientific and futuristic nature. The future of vocational agriculture depends upon a willingness of the agricultural education profession to analyze current programs and adjust them to meet the changes of today's rapidly advancing biotechnology. Objectives should be established to update the instructional program with emphasis on agriscience skills. Basic plant and animal research, food and fiber processing are expected to provide the most significant employment opportunities for graduates with expertise in agriculture and natural resources. Supervised Occupational Experience programs, FFA, laboratory experiences and class room instruction must all be modernized to reflect this new image.

The views expressed by Kahler (1989, p. 7) were more or less in line with the above passage:

> The agricultural industry has changed dramatically from what it was when the vocational agriculture program began in 1917. It has emerged as a highly technical, basic and applied science. When one surveys the horizon and observes the emerging agricultural technology, it challenges one's imagination almost to the point of disbelief. When these developments are compared with the content of the vocational agriculture program and its potential for providing instruction germane to these developments, it becomes apparent that a major restructuring of the focus and content of the program will be necessary to keep pace and do its part in teaching about these developments. Instruction in agriculture will require more emphasis on the biological and physical science principles undergirding these developments.

The seriousness of the failure to include the biosciences was noted by some authors. Failure to include the biosciences into instructional materials also delays the transmission of vitally important information in the field of biotechnology (Mayer and McInerney, 1984). Sutphin (1985) supported the statement by expressing that failure to include the biosciences in the vocational agriculture curriculum may also jeopardize the credibility of the local agricultural program and place teachers at a major disadvantage in their effectiveness. It is clearly understood from these statements that technological developments cannot be applied in the field of agriculture if vocational agriculture teachers lack knowledge about how to use the biosciences in the study of agriculture.

Realizing the need for the infusion of the biosciences into vocational agriculture, the Iowa Technical Committee on Biotechnology has emphasized that serious consideration to be given to the following recommendations according to Martin (1987, p. 9).

1. A three to five year project to be funded to develop instructional and student activity models for dissemination to teachers via inservice education to implement a curriculum with a focus on the expanded "sciences" and "technologies" of agriculture emphasizing the seven occupational areas of the industry.

2. A condensed model curriculum plan should be developed based on the new agriculture and its emphasis on the biosciences stressing the seven occupational areas of the agricultural industry and its global impact.

3. Agricultural educators should promote the concept that the agricultural industry is highly dependent on science and technology and offers many career opportunities for people.

4. Teachers should be encouraged to incorporate the basic sciences with the study of plant and animal sciences ie. genetics, microbiology, and biochemistry.

5. Teachers should have had at least a basic course in genetics to insure the students in agriculture get the information /knowledge base necessary for the "new" agriculture of the future.

6. Change the name of the educational program in agriculture from "Vocational Agriculture" to "Agricultural Science and Technology."

7. National and state award programs should be initiated to outstanding agriscience teachers.

He further summarized:

> The need for developing an awareness of the scientific foundation of the agricultural industry is becoming one of the major issues of our time. It has become increasingly apparent that if a person is to be considered educated in agriculture, he/she must be cognizant of the interrelationships of various agricultural systems and the scientific foundation upon which they function. It is no longer sufficient to only know about how to produce food and fiber. Professionals in agriculture must have an education based on the sciences and be able to adapt scientific principles to the practical applications of technology. Additionally, an informed society must have a basic understanding of agriculture and the sciences that constitute its framework. Science, technology, agriculture, and economic and social development are unavoidably interwoven. If we are to advance as a society and a world community it is critical that students in general, and students of agriculture in particular, learn as much as possible about the sciences, including biotechnology and how these sciences can be put to practical use.

An initial move in this direction was a five year plan recently adopted by Iowa in order to improve vocational and technical education in agriculture in secondary public schools. The Agricultural Science and Technology program was recommended by the Iowa Department of Education and by the Iowa Vocational and Technical Agricultural Improvement Cadre and the Iowa Biotechnology Technical Committee.

Role of Biosciences in Developing Career Opportunities

According to Stansbury and Coulter (1986), farming and ranching are often the most visible parts of our food and agricultural system, but ultimately accounts for only about one-sixth of employment in the food and agricultural system which accounts for one-fifth of the national employment. Certain knowledge regarding careers in the field of science and technology is essential before converging our focus into the area of study. Harris (1989, p. 5) in the following quote explained how vocational agriculture lay the foundation for science related agricultural careers:

> Modern agriculture offers a future of rapidly expanding career opportunities, especially in the twin areas of technology and business. Many opportunities will emerge from America's leading edge fields of biotechnology and communications, perhaps as a genetic researcher in California or as a market analyst in New York. Still more agri-careers, non-existent today, will develop in food processing and technology and in non-food uses of agricultural crops. The diverse opportunities in agricultural careers cover more than 200 career fields available to those interested in producing, processing and marketing food and fiber. This largest industry employs one-fifth of the nation's work force. Many of today's agricultural careers are enmeshed in the biological sciences and will be even more so in the twenty first century. The foundation for these careers often laid in high school levels with the vocational agriculture instructor (FFA advisor), 4-H club leader, biology or other science teacher or with a career counsellor. These knowledgeable advisors have a critical role in providing sound information and counsel to those inquiring about agricultural careers.

A passage extracted from the Long Term Farm Policy to Succeed the Agriculture and Food Act 1981, (p. 11), provided a clear understanding regarding diversified career opportunities available in the field of agricultural science and technology:

Needs assessment for the Food and Agricultural Sciences would give emphasis to the Joint Council's recognition of the vital need for assured supply of human capital.

Sec.1402 (8). New federal initiatives are needed in the areas of :
(F) teaching programs involving state-of-the-art approaches to curriculum innovations such as a systems approach to problem solving, information systems via computer applications and ethics in the food and agricultural sciences.

Sec 1402 (10). National support of cooperative research, extension, and teaching efforts must be affirmed and expanded at this time to meet major needs and challenges in the following areas:

(G) Scientific Expertise Development:
America's food and agricultural system is seriously threatened by impending shortages of highly qualified scientists, managers, and technical professionals. Insufficient numbers of highly capable students are entering advanced degree programs in basic agricultural science disciplines and technical specialities to meet the nation's needs for food and agricultural scientific expertise. Currently there are severe shortages of scientific expertise in such areas as biotechnology, food sciences, human nutrition, animal health and reproduction, soil and water sciences, international marketing, and agricultural engineering.

Sec. 1417 (3). USDA's higher education programs unit has funded a number of pilot projects with funds provided by the Agricultural Research Service which has a vital interest in assuring a supply of well educated and trained scientists. These projects include the following, all of which have supported the development of food and agricultural expertise:

(i) Publication for high school science teachers
This initiative involves co-sponsorship of a project by the Council for Agricultural Science and Technology (CAST) to enhance high school science teachers' understanding of agricultural research missions. Periodic publications, directed to high school science teachers, focus on selected agricultural science topics such as water quality, food safety, and plant molecular genetics.
(ii) Student recruitment strategies
This project is directed toward two broad areas. It seeks to enhance the image of agricultural careers among graduates from urban and suburban high schools and to increase the enrollment of these

> students as well as students from high school vocational agriculture programs.

One might be interested while reading paragraph (ii) of Sec. 1417 (3) of the Long Term Farm Policy Act 1981 that the students of vocational agriculture programs are also considered for agricultural careers in the areas of agriculture science and technology. The above passage could be related to the recommendation of Iowa Vocational and Technical Agriculture Improvement Cadre (1987), Iowa State University and the Iowa Technical Committee on Biotechnology which focused on developing an "Agricultural Science and Technology" program. Further these advisory groups also recognized that educational programs must move from a narrow, production oriented emphasis to a more contemporary curriculum that prepares students for changing employment opportunities in the areas of science and high technology careers in agriculture (Martin, 1988a). The statement was supported by Moss (1989, p. 7) who explained:

High school vocational agriculture programs that once prepared students to become farmers are being broadened to prepare youth for occupations in industries that support production agriculture. Many aren't yet aware of how many exciting career opportunities the agriscience program offers.

Smith (1989) provided an example where he pointed out that the advent of new high-value crops would be especially important for people who seek specialized careers in the supply and processing of emerging agricultural products. O'Kelley (1985, p. 23) also explained the contribution of the biosciences to career opportunities in the following statement:

> Vocational agricultural instruction can and must make a major contribution to career education at the secondary school level. The major emphasis at first will be on broad occupational preparation in the field of agriculture. As the number of occupational areas of

> agriculture are on the increasing trend in agriscience in the near future, the students need to be prepared in this area.

According to Duval (1988), today's agriculture students are reaching for career opportunities that extend far beyond the familiar face of agriculture in the local community. Further, Vold (1988) in his efforts to link vocational agriculture programs and job opportunities expressed that preparing young people for future job opportunities has always been the primary motive of vocational agriculture instructors; and making modifications which can better accomplish this remains as the next step continuing that proud tradition.

Meeting the Needs Vocational Agriculture Students

Apart from the preparation of students for diversified occupations, infusion of the biosciences can play a significant role in meeting the needs of students according to some educational researchers. Duval (1988, p. 20) cited an example of this premise:

> The agriculture department of Boonville, California, was a place where unmotivated and disinterested students were placed with a low enrollment of seventy-five students prior to the implementation of the agriscience program. Today, the same department has one of the most respected agricultural programs in the U.S. with growing enrollment after agriscience was incorporated into the vocational agriculture program.

Perry's (1989, p. 32) support of the above statement could be understood from the following passage:

> Students from low income groups and students who are potential dropouts can be encouraged by vocational agriculture instructors in their individual areas of interest while incorporating science related SOE programs. For example, in a green house the students can help to plan and construct, grow tomatoes, bedding plants and herbs to sell at local markets.

McKay (1988), an agriculture teacher, narrated his experience on how agriscience meets the needs of students:

> As students take ownership in projects, they discover a purpose in being in school. When they see that more effort and improved methods mean more earnings, pride and responsibility develop. They ask more questions. They want to know why things happen and how things work. They develop skills in problem solving, decision making, and critical thinking. In dealing with their own research and ownership enterprises, they feel important and valuable.

He concluded by suggesting that the agricultural instructors should convince the public, the core science teachers and the school board that science is indeed a part of the agricultural program. On the other hand, one of the agricultural instructors surveyed by Vold (1988) contradicted the above view by expressing his concern that the type of student that is directed toward the vocational agriculture program is not the caliber of student that would appreciate the biosciences. However, high school vocational agriculture courses could begin to hold more interest for academic students interested in biochemistry and genetics.

Science Credits for Bioscience Instruction

It was understood during the literature review that some agricultural educators viewed that science credits should be offered for agriscience instruction. Lehnert (1988) provided a case where he showed that a vocational agricultural teacher, Robert Thompson in Vicksburg, Michigan was teaching the biosciences quite satisfactorily with the cooperation of the science department and offered science credits for it. Thompson reported "Our beginning agriculture course is natural science with an agriculture flavor. Instead of dissecting frogs, the kids dissect chickens." He concluded saying "This new effort gives students a required science credit."

The above statement was supported by Duval (1988) when she explained that many agriculture instructors requested and received science credits for their students by defining and developing new curricula on the agrisciences. Three agricultural educators Williams (1987), Martin (1988a), and Kahler (1989), were also of the same opinion. This opinion is supported by the Committee on Agricultural Education in Secondary Schools (1988) which recommended that agricultural courses sufficiently upgraded in science content should be credited with satisfying college entrance and high school graduation requirements for science courses in addition to the core curriculum. On the other hand, Amberson (1989) disagreed with the above recommendation by asserting that science should be left to the scientific community and science is doing well without the help of agriculture teachers. However, he suggested that agriculture teachers could teach courses in agriscience that might substitute lower level science courses though not science courses that are essential for the college preparation. Further, one of the agricultural instructors in Iowa expressed his concern over this matter by stating, "I would love to teach the biosciences, but I can't convince my principal to give it science credit" (Vold, 1988).

Role of Biosciences in FFA and SOE

Some authors argued that more FFA activities could be developed if the biosciences are infused into vocational agriculture programs. Duval's (1988, p. 19) statement provided enough information on the importance given to agriscience by the National FFA Organization:

> The National FFA Organization has received agriscience and the emerging technologies as being of primary importance to the future of agriculture and the organization. It encourages students and teachers to participate in agriscience activities and to develop the skills and knowledge needed for new careers in agriculture and have provided award programs to recognize their efforts.

Perry (1989) supported the above statement by expressing that through an active FFA program, the vocational agriculture students could have an opportunity to practice communication and presentation skills related to agriscience. According to the Committee on Agricultural Education in Secondary Schools (1988, p. 41):

> The FFA is also supporting efforts to develop new science-based instructional materials and special activities to foster understanding of scientific and technological developments important to the agricultural, food and fiber industries. The growing importance of the food processing and marketing industries and the emergence of new jobs involving applications of biotechnology to agriculture may open up new SOE opportunities in urban and rural communities.

In addition, the state action plan developed at the National Conference on Agriscience and Emerging Technologies held in Orlando, Florida in 1988 indicated that an agriscience center should be organized at the FFA summer camps (Williams and Pope, 1989). Burton's (1989) views were also in line with the above statement when he stated that SOE should provide students with experiences in biotechnology in agriculture, animal sciences and other areas congruent with the academic needs and of student and employment demands. For instance an urban student can develop skills in plant science and green house management through placement arranged by the local vocational agriculture teacher.

Biosciences and Emerging Technologies

Smith (1989) indicated that rapidly evolving technologies have always pressured agricultural educators to keep abreast of developments and create fresh curricula and biotechnology is no exception. In addition, Williams and Pope (1989) stated that the National Conference on Agriscience and Emerging Occupations held in Orlando, Florida in 1988, emphasized the incorporation of scientific principles related to agriculture. He further listed the state action plans for upgrading and expanding agricultural programs shared at the conference which supported the recommendations of the Iowa Technical Committee on Biotechnology (1987):

1. Forming curriculum improvement committees.
2. Developing agriculture courses to serve as science credits.
3. Infusing agriscience into the curriculum.
4. Emphasizing scientific principles in classroom and laboratory activities.
5. Cooperating with other states in developing new curriculum materials.
6. Expanding SOE options.
7. Providing inservice for teachers on new technologies by cooperating with universities.
8. Upgrading the technical skills of teachers.
9. Changing the instructional program from "Vocational Agriculture" to "Agricultural Science and Technology."
10. Developing an agriscience center at FFA summer camps.
11. Maintaining occupational and vocational focus.

Malpiedi (1989, p. 5) in her effort to link science, emerging technologies, and agricultural education stated that:

> Whether we call this beast agriscience - the application of science in agriculture, agritechnology - applying the latest technological advances to agriculture, or biotechnology - the integration of genetic engineering, cellular hybridizations, and fermentation and bioprocessing, it is evident that studies in and about agriculture are changing. Agriscience and emerging technology scare many of us who are unfamiliar with the terminology and processes. Agricultural educators, are among the best at teaching people how to grow and adapt with change. We need to find ways to help vocational agriculture students with the ethics of biotechnology as well as how to benefit from the opportunities created in the food and fiber industry.

Smith (1989, p. 11) provided certain specific examples where the newly evolved technologies find their place in the farmstead and also stressed the need for learning such technologies:

1. Dairy, beef, and pork producers' recent use of genetically engineered growth hormones provide an example of the need to teach about biotechnology. As the hormones are first tried, farmers need to know of the new possibility to increase milk, beef, and pork production. Although farmers do not need to learn about genetic engineering, hey do need to learn how to administer the hormones.

2. Genetically engineered plants now under development could allow farmers to control ripening and harvest to maximize profit in fluctuating markets.

3. New herbicide-resistant crops will create flexibility in crop rotation patterns.

4. Genetically engineered bacteria can now cheaply produce genuine vanillin and this would have a profound impact on international agricultural economy.

5. New biotechnological techniques will allow for sensitive monitoring of soil and water, expanded low-till farming, and decreased use of pesticides.

Some other authors have also contributed to this list:

6. Bacteria used in producing fermented foods can be manipulated to improve fermentation efficiency, nutritive value, flavor, and appearance of the final product. For instance, bacterial manipulation using rDNA technology reduces the ripening of cheddar cheese which normally requires a storage period of six to twelve months.

7. Livestock embryos can be frozen, stored and later transferred to surrogate mothers, greatly enhancing their use as well as the geographic superior genetic materials. Through the embryo transfer technique, one superior donor cow can produce 110 calves which is the reproductive equivalent of about 150 years in normal cow/ calf production time (Doyle, 1985).

The above list is quite enough to support what Harlander and Garner (1986) has aptly forecasted that by the year 2000, the worldwide market for biotechnology derived food and agricultural products could be valued at tens to hundreds of billions of dollars. One might understand from the above statement that extensive agricultural research performed by the public and private agencies resulted in changes in agricultural production practices. As these research efforts have opened new applications in agriculture, more programs related to these applications are required at secondary and post-secondary levels (Moss, 1989). On the other hand, biotechnology has also certain limitations that agriculturalists must consider according to Smith (1989, p. 13):

Most crops and animal biotechnologies now involve single gene traits such as specific disease resistance. The single gene traits are refinements but are not major modifications that drastically increase productivity.

Jenitor (1989, p. 43) illustrated a case to show how the learning of basic sciences would help to solve problems in the field:

> Bovine leukemia cost the U.S. over $ 44 million annually, replacement of diseased cattle, lost milk production and associated costs. Problems in dealing with the virus are that cattle can be infected and show no signs of disease, and not that all infected cattle are actually contagious. The basic knowledge on the nature of virus and how this virus integrates into the chromosome of infected animals would help the producers to identify and either segregate or get rid of animals that might be infectious.

Related Studies

Vold (1988) conducted a state-wide survey of the vocational agriculture instructors in the state of Iowa to study their perceptions on the importance and expansion of the biosciences in the agricultural curriculum and came out with significant findings. He found that the agriculture instructors seemed to overwhelmingly agree on both the importance and the opportunities for expanding the biosciences into the study of agriculture inspite of their concerns about funding, declining enrollments and doubts about students' apprehensions about these new changes. Further it was noted that there were certain similarities in the recommendations made by Vold (1988) and the Iowa Technical Committee on Biotechnology (1987):

> Teachers should be encouraged to incorporate basic science into the study of animal and plant science ie. genetics, microbiology, and biochemistry. Agricultural educators should promote the development of linkages with industry to emphasize the application of science as well as occupational opportunities. Agricultural educators need to emphasize to their students the tremendous job opportunities and career ladders opening up today in the rapidly emerging world of agricultural science and technology.

Moreover, Vold explored certain areas where further research should be concentrated:

* Articulation of agricultural science with basic instruction at the secondary level.
* A pilot program concentrating specifically on infusing agricultural science skills into a program which may not presently include such instruction.
* Development of curriculum models and specific classroom activities based upon areas of highest need as identified in this study.

Moss (1986) in his study at Louisiana found similarity between the curriculum in vocational agriculture and some high school science course. He found that out of the seventy-six instructional objectives, twenty of them overlapped with two or more science courses.

Another study conducted by Bonzi and Leising (1988) in California revealed that the majority of agricultural programs received science credit for agricultural courses. However, they left it to further research to determine which biological science competencies needed to be fulfilled. Gallatin and Holley (1988) conducted a study in order to identify the science competencies to be included in the basic core curriculum of vocational agriculture in Oklahoma. Their findings revealed that nearly eighty percent of the vocational agriculture core curriculum selected objectives were validated as science related to biology and seventy-eight percent in the general science area. This study was more general in nature as it dealt with science in general and varied from the present study which was exclusively on the biosciences. But the study had a valid recommendation which was closely related to the objectives of the present study:

> Vocational agriculture should make a concerted effort to develop and include more science theory being taught along with practical application.

A summer science institute organized by the University of California, Davis for agricultural teachers focused on integrating biological concepts into agricultural curriculum (AATEA, 1988).

Summary

The review of literature presented a diversified view of leaders in agricultural education concerning the fundamental aspects of the biosciences in the study of agriculture. It was understood from the literature search that how the principles and concepts of the biosciences laid the foundation for understanding agricultural biotechnology and its role in the present day agricultural industry. Further, it was interesting to find that the terms - bioscience, agriscience, agricultural science, and basic sciences are used interchangeably by many authors. The literature review also established the rationale for the need for the infusion of the biosciences into the study of agriculture. Some authors made it clear that if we were to keep pace with the growing technology as a result of research through public and private agencies, science related to these technologies is essential for vocational agriculture students. The significance of the infusion of the biosciences can be clearly understood from the views of agricultural educators who emphasized the change of the name of the secondary school agricultural program from "Vocational Agriculture" to "Agricultural Science and Technology." It was evident from the literature review that little work had been done to study the perceptions of vocational agriculture instructors regarding the biosciences.

This information provided the theoretical framework for conducting the study on the perceptions of vocational agriculture instructors regarding the infusion of the biosciences into the study of agriculture. Further, it is important to note that the recent nature of most of the literatures is a clear indication that significance given to this area of study is on the increase by the professionals. Hence, as Vold (1988) rightly pointed out that if industry and business continue to mandate a stronger background in the sciences and if agriculture continues to place the U.S.A. in a worldwide leadership role, there is great reason for optimism in this movement toward agricultural science infusion into secondary school programs.It can be concluded that if the concepts and products of biotechnology are well taught, we will achieve a smooth transition to agriculture that uses this technology as pointed out by Smith (1989).

CHAPTER III. METHODS AND PROCEDURES

The overall purpose of this study was to identify the perceptions held by teachers of agriculture in the U.S.A. regarding the infusion of the biosciences into the study of agriculture. The following specific objectives were developed in order to provide a framework for conducting this study:

1. To identify the level of importance of the biosciences in vocational agriculture as perceived by agriculture instructors.
2. To identify the degree to which vocational agriculture instructors would increase instruction in the biosciences given selected resources and inservice education.
3. To determine perceptions held by vocational agriculture instructors regarding teaching the biosciences.
4. To compare various groups of respondents regarding their perceptions on selected bioscience competencies and 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 for the study, and summary.

This study was initiated as a follow-up project of the Iowa Technical Committee on Biotechnology (1987). The Committee headed by Dr. Robert A. Martin of the Department of Agricultural Education, Iowa State University was appointed by the Iowa Department of Education to investigate the potential impact of biotechnology on the study of agriculture at the secondary education level. The committee, consisted of fifteen members representing various industries and areas of interest including agronomy, animal science, horticulture, veterinary medicine, vocational education, career education, and the biotechnology industry. The committee developed an inventory of competencies appropriate for the agriculture curriculum related to biotechnology. The committee also formulated a curriculum guide for the Agricultural Science and Technology programs in secondary schools.

Research Design

The research approach used in this study was a descriptive survey method. This method has been validated as a means of gathering information for studying the attitudes and perceptions of people. The responses for a perception study can be measured quantitatively using scales. The information gathered must be analyzed to assess interrelationships between variables and the principle of random sampling must be observed (Web, 1985).

Population and Sample

This study was national in scope. Vocational agriculture instructors from all fifty states were included in the population. The target population for the study was 10,102 vocational agriculture instructors of the country. The vocational agriculture instructors were identified from the Agriculture Teachers Directory for the year 1987 published by the National Vocational Agriculture Teachers Association of the U.S.A.

An adequate sample size for this study was determined to be five percent of the population (Seshan, 1979). A proportionate stratified random sampling method was adopted in order to select the sample. The principle of proportionate stratified random sampling was described by Seshan (1979, p. 62) as follows:

> Often, the population is heterogeneous. When the researcher knows that several sub-populations exist, the total population may be subdivided into two or more sub-populations, called strata. The researcher carries out appropriate sampling procedures within each stratum and thus retains the equal probability assumption. Through proportional allocation of members to each stratum, each stratum contributes to the sample, the number of members proportional to its size in the population.

To ensure that the sample was representative of all groups, the population was stratified into six groups based on the six regions of the National Vocational Agriculture Teacher Association (NVATA) of the country (Hendry, 1987). A proportionate sample of five percent was drawn from each group (region) based on the number of active vocational agriculture instructors in the country. The following steps were followed to select the sample:

1. The total number of population in each group and the number of samples required for each group (five percent of the population of the group) was entered into an AppleIIe personal computer.
2. A random number program was run in the computer in order to select the required samples randomly from each group.
3. The instructors listed in the Agriculture Teachers Directory (Hendry, 1987) were assigned code numbers separately for all the six regions.
4. The random numbers generated by the Apple IIe computer were matched with the assigned code numbers in the directory and the corresponding vocational agriculture instructors were drawn.

Thus the representation of all six regions of the National Vocational Agriculture Teacher Associations (NVATA) was achieved by the proportionate stratified random sampling.

Instrumentation

The instrument used in this study was primarily designed to identify the level of importance of the bioscience competencies and the extent to which instructors would increase instruction in these competencies given selected resources and inservice education. The instrument also contained questions to determine perceptions held by vocational agriculture instructors regarding teaching the biosciences.

The following steps were adopted in order to develop the instrument used in the collection of data for this study:

1. A list of 149 bioscience competencies was compiled based on the topic areas and the curriculum guide developed by the Iowa Technical Committee on Biotechnology, knowledge obtained through discussions with the committee, related literature and experience of the investigator. These competencies were developed in six broad disciplines of the bioscience namely: (1) plant science, (2) genetics, (3) animal science, (4) microbiology, (5) soil science, and (6) food science. The compilation of the knowledge and skill statements was done utilizing the criteria listed below:
   a. Knowledge and skills directly contribute to the applied sciences.
   b. Knowledge and skills have a direct impact on student career opportunities.
   c. Knowledge and skills have a relationship to the seven occupational areas of the agricultural industry.
   d. Knowledge and skills reviewed and approved by a panel of experts.

2. Likert-type scale with points ranging from 1 to 5 was used to collect information regarding teacher perception in the following areas:
   a. Extent to which this knowledge or skill area was important.
   b. Extent to which the instructor would increase instruction in this knowledge or skill area given instructional materials and inservice education.
3. Nineteen statements to determine perceptions held by vocational agriculture instructors regarding teaching the biosciences were framed. These statements formed the second section of the questionnaire.
4. Questions pertaining to respondents' demographic information were asked in section three of the questionnaire in order to gain an in-depth knowledge of the participants of this study. This section was also provided with some open space for the respondents to express their free thoughts regarding any part of the questionnaire and also their suggestions to make the study more useful to them.
5. The first draft of the proposed questionnaire was reviewed by the writer's committee. It was suggested that competencies based on "hands on experience" should be included. The subject areas which were not directly related to biosciences were deleted as per the suggestions.
6. The first draft was revised and a second draft was formed incorporating the revisions.
7. An expert committee, represented by the members of the Iowa Technical Committee on Biotechnology and vocational agriculture instructors was formed in order to establish the content validity of the questionnaire.

8. The second draft was sent to the expert committee. The committee evaluated the content of the questionnaire in terms of its interpretation of correct meaning, simplicity, ease of understanding and appropriateness to the objectives of the study. The length of the questionnaire was also reduced to 127 as suggested by the writer's graduate committee.
9. The final draft of the questionnaire was pilot-tested with a group of vocational agriculture instructors who were not members of any sample strata.
10. Following the pilot test, minor modifications were made based on the responses of the pilot testing. A few relevant items suggested by the respondents of the pilot test were included and a final draft was then constructed and copies to be used were printed. A copy of the questionnaire used in the study can be found in Appendix C.
11. The proposal along with the questionnaire was submitted to and approved by Human Subjects Committee, Iowa State University

Collection of Data

The questionnaires were mailed to the participating vocational agriculture instructors. Enclosed with each questionnaire was a cover letter explaining the nature and scope of the study, and a self-addressed stamped envelope. A copy of the cover letter is included in Appendix C. The individuals in the sample were asked to complete the questionnaire and return it to the investigator within three weeks of the receipt of the questionnaire. A code number was assigned to each participant and it was marked in one corner of the last page of the questionnaire for identification and follow-up purposes.

A follow-up procedure was initiated by the end of the sixth week after the first mailing. A follow-up letter along with another copy of the questionnaire was mailed to all participants of the study who failed to respond the first mailing. A copy of the follow-up letter can be found in Appendix C. The number of questionnaires returned by the 505 sample vocational agriculture instructors after the second letter was 168. The response rate was thirty-three percent.

Table 1. Rate of return of questionnaire by respondent groups

Respondent groups		Questionnaires mailed	Questionnaires returned
NVATA Region I	N	72	38
	%	100	52.7
NVATA Region II	N	114	50
	%	100	43.8
NVATA Region III	N	67	39
	%	100	58.2
NVATA Region IV	N	88	43
	%	100	48.8
NVATA Region V	N	95	41
	%	100	26.3
NVATA Region VI	N	69	26
	%	100	23.1
Total	N	505	237
	%	100	47.3

A second follow-up was taken after two weeks from the first follow-up. A post card (Appendix D) was mailed to the non-respondents emphasizing the significance of their responses and our eagerness to receive the completed questionnaires. This procedure generated 237 responses and the final response rate was forty-seven percent.

A non-respondent follow-up was conducted as the final procedure to collect data from the non-respondents. As a final process of data collection from the respondents, this method would yield valid information according to Web (1985). Five percent of the non-respondents was found to be adequate for the non-respondent follow-up study (Seshan, 1979). First, the non-respondents were segregated from the sample list. A random number program was run in the Apple IIe personal computer to select the sample. A total of thirteen non-respondents were selected.

Every fourteenth item was identified from the questionnaire list and thus ten items were chosen. The sample non-respondents were called by telephone and their perceptions regarding the selected ten items were asked. If the selected non-respondent was not available for the first time, he/she was again called. The follow-up of non-respondents yielded no significant practical or statistical differences between the responses of those participating in the survey and those choosing not to participate.

Statistical Analysis

The data collected from the respondents were checked, coded, key punched, verified, and analyzed using the Iowa State University Computation Center facilities. The statistical procedures used to summarize and analyze the stored data were the following:

1. The Statistical Package for the Social Sciences (SPSSx) program was used to compute frequency counts of the stored

data. This procedure was used to locate incorrect data that was missed during verification procedure.

2. A Cronbach alpha was computed for all the bioscience competencies in order to evaluate the reliability of the instrument.
3. The mean scores and standard deviations were computed for all the listed bioscience competencies to determine the level of importance of the bioscience competencies.
4. This statistical analysis was repeated to determine the degree to which vocational agriculture instructors would increase instruction in the listed bioscience competencies.
5. A one-factor analysis of variance (ANOVA) was computed in order to compare the six regions regarding the level of importance of competencies as perceived by agriculture instructors.
6. This procedure was repeated to compare the six regions regarding the degree to which vocational agriculture instructors would increase the instruction in the listed bioscience competencies.
7. The Tukey method was used as a post-hoc analysis to identify where the differences among the regions existed.
8. To test for differences between the means of the degree of competence of respondents and non-respondents, the T-test was used at the 0.05 and 0.01 levels of significance.
9. To establish certain relationships between selected demographic factors and perceptions of agriculture instructors, Pearson correlation coefficient was used at the 0.05 level of significance.

Assumptions of the Study

1. Accurate, objective and unbiased information was provided by vocational agriculture instructors in each of the areas of questionnaire.
2. The stratified sample of the vocational agriculture instructors proportionately represented all the six regions of the National Vocational Agriculture Teacher Association of the U.S.A.
3. Respondents evaluated the competencies in terms of a "realistic" perception of the role of vocational agriculture instructors.

Limitations of the Study

1. The study was limited to bioscience competencies in secondary school agricultural education program and did not consider any other pertinent competencies related to secondary school agricultural education programs.
2. The competencies in the instrument reflect those judged important for secondary school agricultural education. The competencies were not intended to be a complete list of competencies for the biosciences as a whole.
3. This study was limited to vocational agriculture instructors and results should not be generalized to core science teachers.

Summary

The overall purpose of this study was to identify the perceptions held by teachers of agriculture in the U.S.A. regarding the infusion of the biosciences into the study of agriculture. The research design used for this study was a descriptive survey method. The target population for this study was 10,102 vocational agriculture instructors of the U.S.A. Proportionate stratified sampling procedure based on National

Vocational Agriculture Teacher Association regions was used to draw the five percent sample and the sample size was 505. A questionnaire containing 127 bioscience competencies was used to collect the data from the respondents. Two follow-up letters were sent in order to increase the percentage of return rate which ended with 237 responses and the final return rate was forty-seven percent. A non-respondent follow-up was conducted as the final procedure where in thirteen non-respondents were called by telephone and their perceptions regarding selected ten items were asked. Mean scores and standard deviations were computed for all the bioscience competencies to determine the level of importance of bioscience competencies and also to determine the degree to which vocational agriculture instructors would increase instruction in the bioscience competencies. A correlational analysis was conducted using Pearson product moment procedures in order to establish certain relationships between demographic factors and perceptions of instructors concerning information of biosciences into the study of agriculture. A one way analysis of variance followed by Tukey method of post-hoc analysis to identify where the differences among the regions of NVATA existed.

CHAPTER IV. FINDINGS

The primary purpose of this study was to identify the level to which selected bioscience competencies were important for the study of agriculture and to identify the extent to which instruction in these competencies would be increased given materials and inservice as perceived by vocational agriculture instructors in the U.S.A. A secondary purpose was to determine the perceptions held by vocational agriculture instructors regarding teaching selected bioscience knowledge and skills and to compare the various groups of respondents based on demographic data. The study identified 127 bioscience competencies which were divided into six broad disciplines: (1) plant science, (2) genetics, (3) animal science, (4) soil science, (5) microbiology, and (6) food science. In addition, the respondents provided demographic information based on age, educational level, years of experience as an instructor, NVATA (National Vocational Agriculture Teachers Association) region to which they belonged and the number of students enrolled in the vocational agriculture program.

The findings of this study were discussed and presented under the following sub-headings:

1. Demographic characteristics of vocational agriculture instructors,
2. Analysis of instrument reliability,
3. Analysis of perceptions held by vocational agriculture instructors regarding teaching the biosciences,
4. Analysis of the level of importance of the bioscience competencies,
5. Analysis of bioscience competencies that would be increased by vocational agriculture instructors,
6. Comparative analysis of various groups of respondents regarding their perceptions on selected bioscience competencies,

7. Open comments of respondents, and
8. Summary.

Demographic Characteristics

The study was national in its scope and all fifty states of the U.S.A. were included in the study. The regions of the National Vocational Agriculture Teacher Association (NVATA) served as the demographic units for this study. The country is divided into six regions according to the NVATA. The number of states in each NVATA region is presented in Figure 1. The western part of the country served as the NVATA region I which has ten states namely Alaska, Arizona, California, Nevada, Utah, Idaho, Oregon, Washington, Wyoming and Montana. The NVATA region II (Louisiana, Arkansas, Oklahoma, Texas, New Mexico, Colorado, and Kansas) comprised of states in the south-western part of the country. The north western states such as South Dakota, North Dakota, Minnesota, Wisconsin, Iowa, and Nebraska formed the NVATA region III. The north eastern part of the country with the states namely Missouri, Illinois, Michigan, Indiana, Ohio, and Kentucky are grouped as NVATA region IV. The states (Florida, Georgia, Alabama, Mississippi, Tennessee, North Carolina, and South Carolina) located in the south-eastern part were grouped as NVATA region V. The eastern part of the U.S.A. served as the NVATA region VI which has thirteen states namely Vermont, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, West Virginia, Pennsylvania, and New York.

The ages of the respondents of the study are presented in Figure 2. The overall average age of the vocational agriculture instructors in the study was found to be 44.4 years. The instructors of the region II were the youngest with mean age of 38.9 years whereas the region V had the oldest mean age of 47.7 years. The differences among NVATA regions

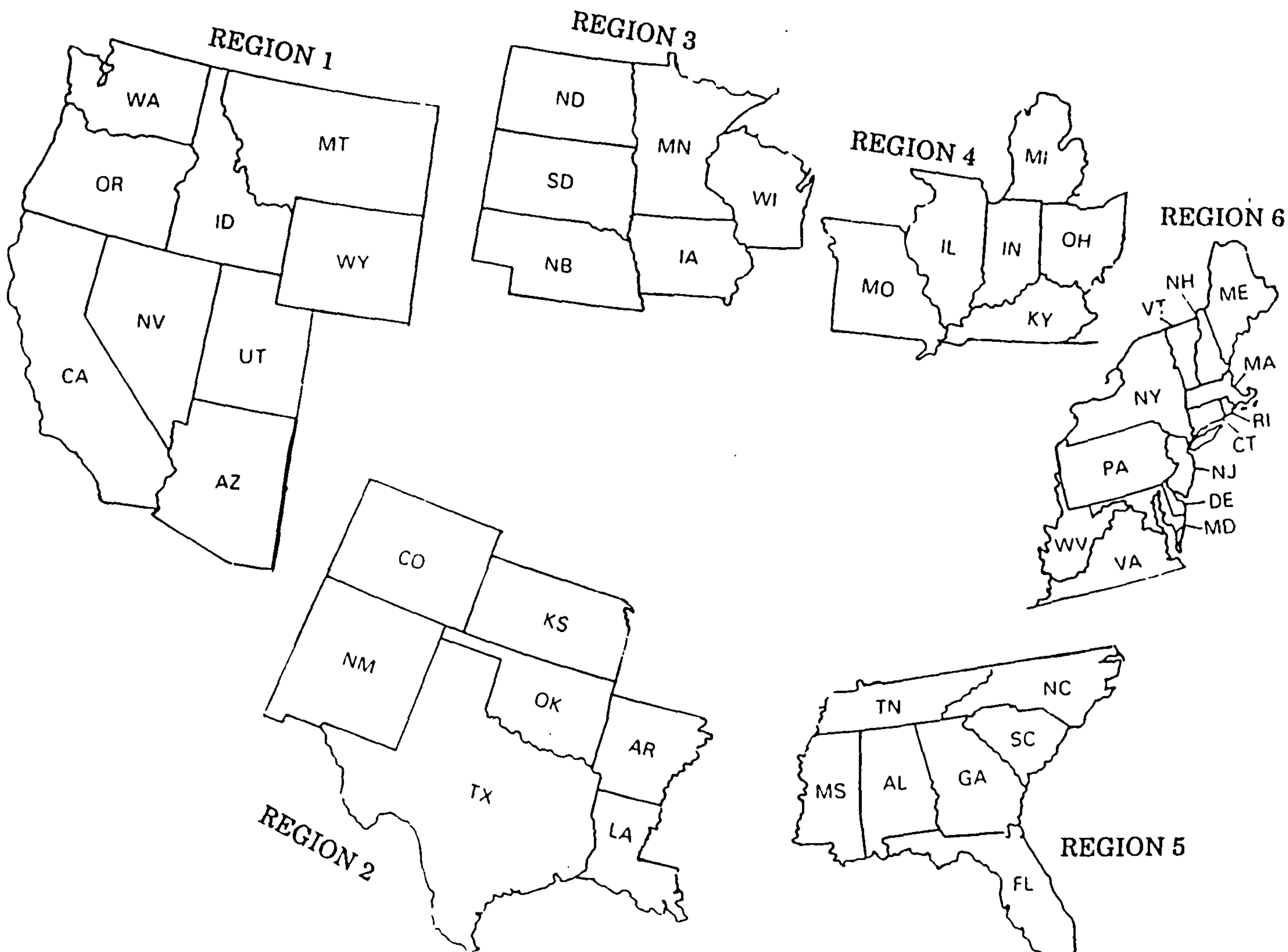

FIGURE 1. NVATA REGIONS

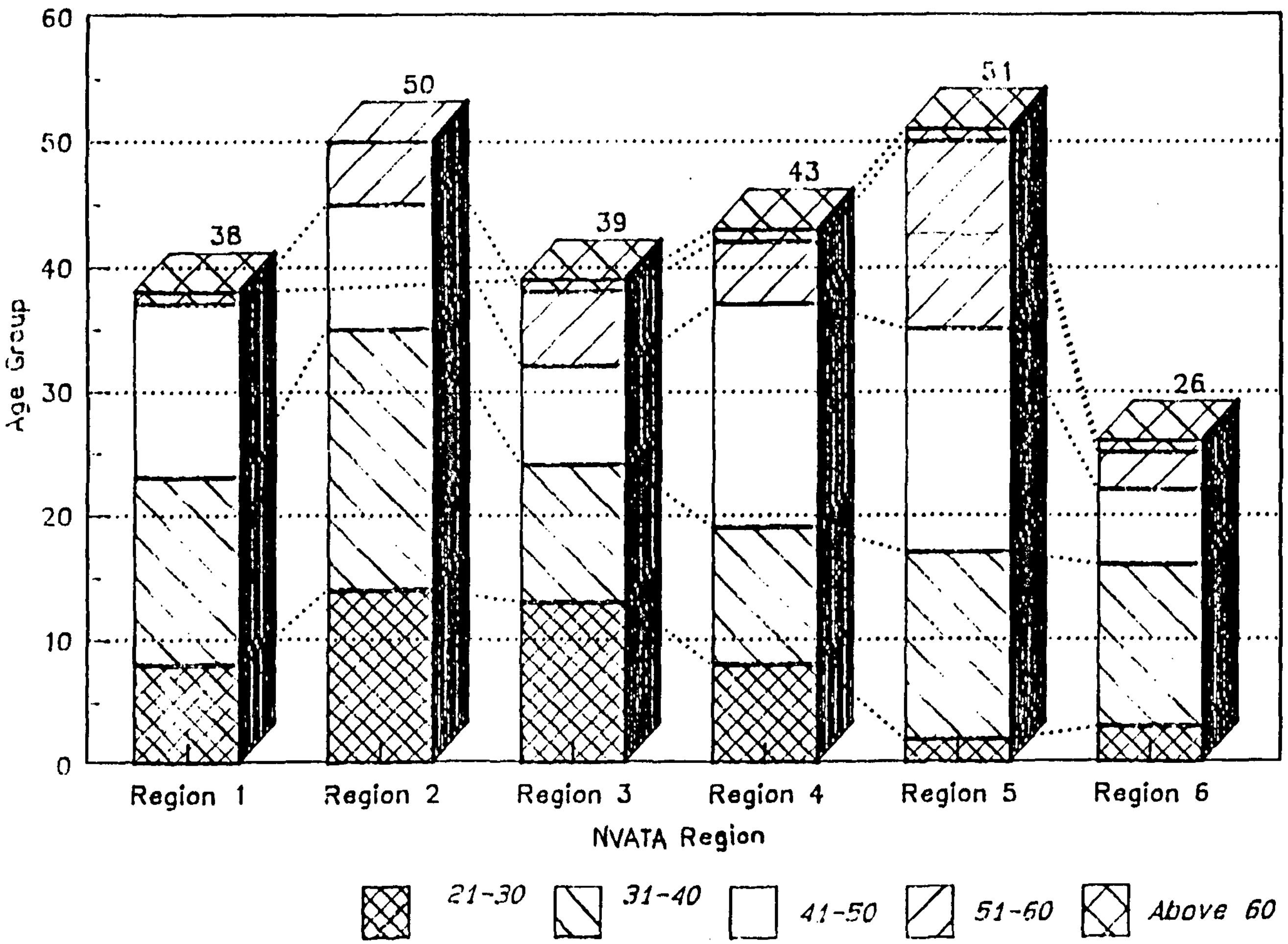

FIGURE 2. DISTRIBUTION OF AGRICULTURAL INSTRUCTORS ACCORDING TO AGE

IV, V and VI were not significant. A master of science degree plus ten credits was the highest level of education attained by the respondents of this study (Figure 3). It was found that 47.3 percent of the instructors possessed a bachelor of science degree whereas 52.7 percent earned a master of science degree. Region II contained the highest number (27) of vocational agriculture instructors with master of science degree. A significant difference in the educational attainment of instructors was found in the region III (bachelor of science (23) and master of science (16)).

The overall average experience of the vocational agriculture instructors ranges from 14.7 years (region II) to 18.5 years (region V). It was interesting to find that 41.3 percent of the participants possessed sixteen years or more of experience as vocational agriculture instructors and 17.7 percent of the participants had experience of one to five years in teaching vocational agriculture (Figure 4).

Analysis of Instrument Reliability

The instrument consisted of a series of bioscience competency statements from six broad areas: (1) plant science, (2) genetics, (3) animal science, (4) soil science, (5) microbiology, and (6) food science. A composite reliability coefficient for the instrument was computed using Cronbach's alpha. The composite reliability coefficients were found to be .80 or above. Based on the magnitude of the composite reliability coefficients, the competency items were considered adequate to measure the perceptions of the vocational agriculture instructors towards the biosciences (Table 2).

Analysis of Perceptions

Table 3 shows the mean scores of the perception ratings of vocational agriculture instructors regarding teaching the biosciences in a

Table 2. Perceptions of vocational agriculture instructors' composite reliability coefficients

Disciplines	Number of items	Reliability coefficient [a]
Plant science	28	0.9635
Genetics	25	0.8431
Animal science	17	0.9669
Soil science	23	0.9710
Microbiology	13	0.9700
Food science	19	0.9763

[a] Cronbach's alpha.

vocational agriculture program. It was interesting to note that fourteen out of nineteen perception statements were ranked between "some what agree" to "strongly agree" by the vocational agriculture instructors. The perception statement "additional instructional materials are required for infusing the biosciences" was ranked first with a overall mean of 4.55. These data showed the need for instructional materials pertaining to the biosciences. Further, this information supports the findings of the Committee of Agricultural Education in Secondary Schools (1988) that there is a lack of proper instructional materials and inservice education relevant to the biosciences. It was observed that no significant gap existed between the first and second items. The second ranked item was

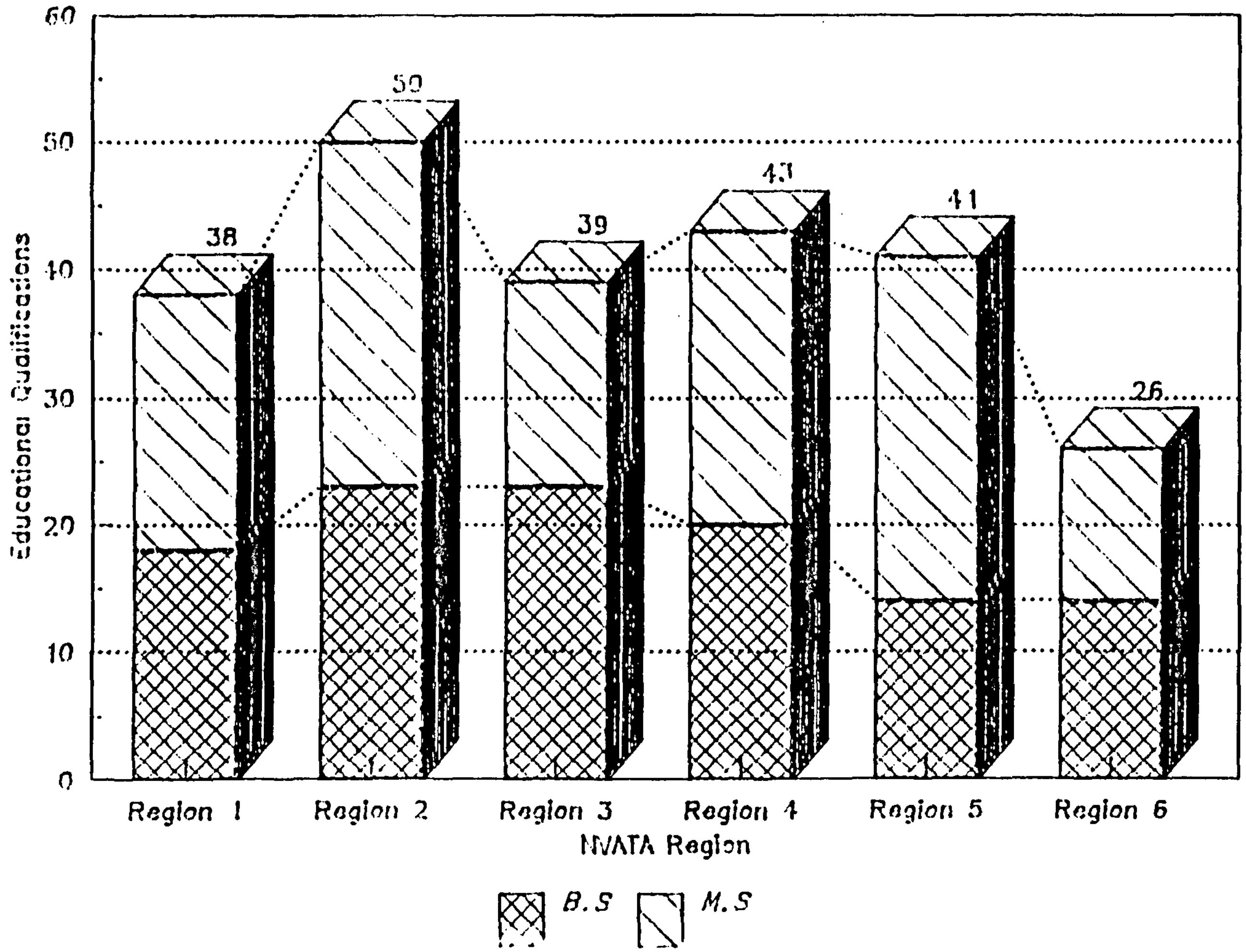

FIGURE 3. DISTRIBUTION OF AGRICULTURAL INSTRUCTORS ACCORDING TO EDUCATION

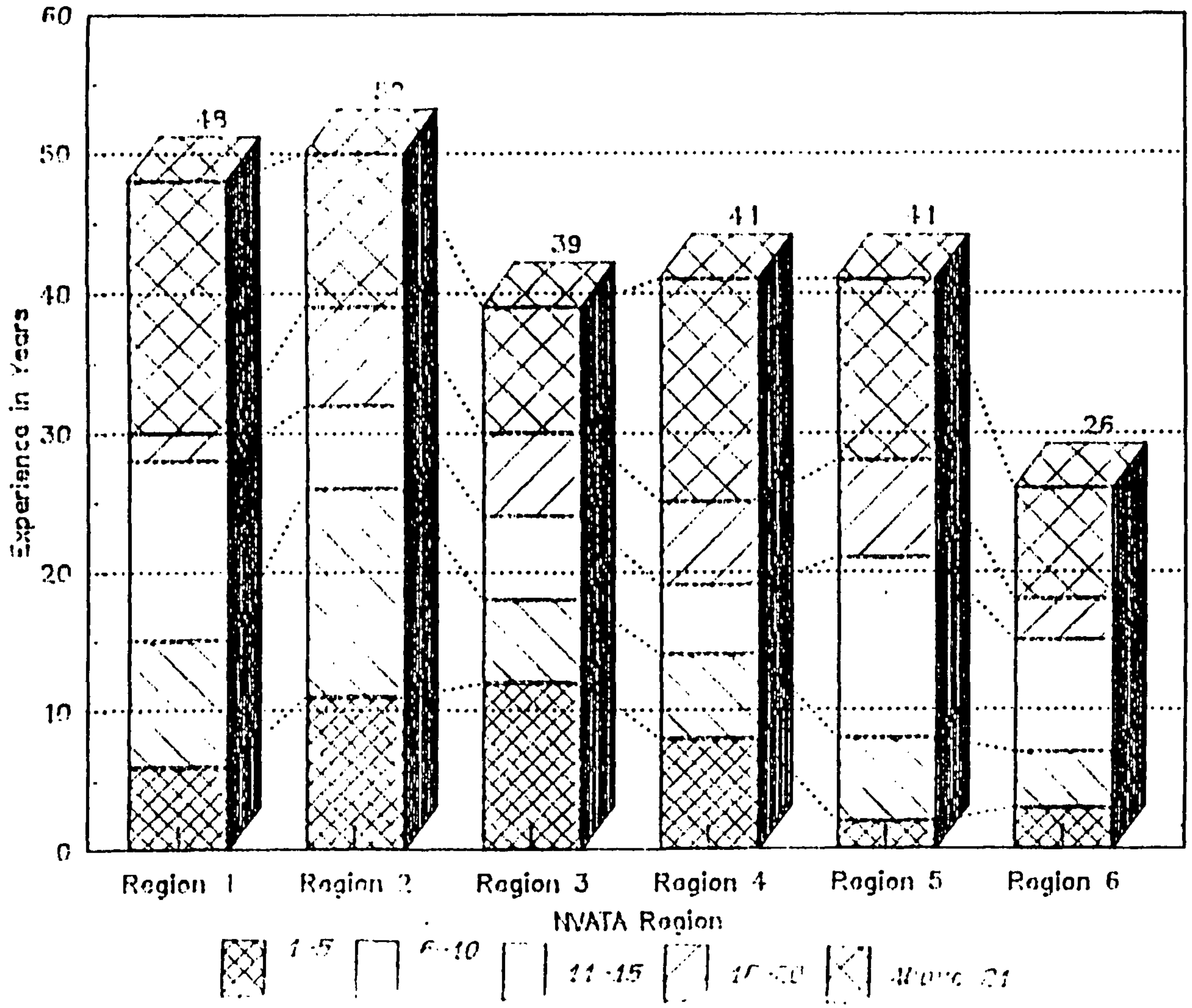

FIGURE 4. DISTRIBUTION OF AGRICULTURAL INSTRUCTORS ACCORDING TO EXPERIENCE

Table 3. Means, standard deviations, and F-values on perceptions regarding biosciences/biotechnology held by vocational agriculture instructors in the U.S.A. (n=237)

Statements	Grand mean	S.D.	F-value
Infusion of biosciences is essential for the study of vocational agriculture	4.17	0.88	0.81
Learning biosciences would help students to better understand agricultural sciences	4.53	0.63	1.21
Students should learn how to explain the processes that occur in plants and animals while learning biosciences	4.33	0.66	1.19
Biosciences would expose students to diversified career opportunities in biotechnology	4.26	0.79	0.51
Learning about the biosciences would help students in solving problems in the real world	3.88	0.93	0.39
Learning about the biosciences would help students in developing skills as they are related to agriculture	4.12	0.77	1.31
Students are interested in learning biosciences as they are related to agriculture	3.58	0.95	0.43
I am interested in relating bioscience skills and knowledge to agriculture	4.31	0.68	0.58
It takes additional time for agriculture instructor to incorporate biosciences into the study of agriculture	4.27	0.95	1.62
Additional instructional materials are required for infusing the biosciences into the study of agriculture	4.55	0.77	0.21

Table 3. Continued

Statements	Mean	S.D.	F-value
Infusion of the biosciences into vocational agriculture would strengthen FFA activities	3.62	0.97	0.43
Biosciences would help in developing Supervised Occupational Experience programs	3.73	0.91	0.58
Biotechnology can be used to increase yields	4.13	0.77	2.51*
Biotechnology can be used to reduce dependency on environmentally undesirable chemicals	4.10	0.82	1.94
With biotechnology, plant breeders will be able to get desired results with greater speed and precision	4.18	0.75	1.91
Biotechnology will be useful for improving disease and insect resistant plant varieties	4.42	0.70	2.51*
Biotechnology will help breeders to improve nutritive values for crops and livestock products	4.38	0.65	1.69
Biotechnology will promote chemical dependency	2.53	1.02	1.14

1= Not agreed
5= Very highly agreed

* F-value required for significance at 0.05 level of confidence with 5 and 236 degrees of freedom was 2.21

the perception statement, "learning biosciences would help students to better understand agriculture" with a mean of 4.53. The perception statement "I am interested in relating bioscience skills and knowledge to agriculture" was also strongly supported (4.31). This information clearly illustrates how strongly the agriculture instructors perceived the importance of learning the biosciences and how essential it is for understanding agriculture.

The agriculture instructors also strongly agreed with the perception statements, "biotechnology will be useful for improving disease and insect resistant plant varieties" (4.42); "biotechnology will help develop new uses for crops and livestock products" (4.38); and "biotechnology will help breeders to improve the nutritive value of food and feed grains" (4.36). These data reflected the felt needs of the vocational agriculture instructors throughout the country. At the same time, the instructors strongly felt that the new effort of incorporating the biosciences into the study of agriculture would take additional time (4.27) for them.

The statement which was probably most relevant to vocational agricultural education namely, "infusion of more of the biosciences would expose students to diversified career opportunities" was supported by the vocational agriculture instructors but it was not ranked among the top five. The vocational agriculture instructors disagreed with the statement, "biotechnology will promote chemical dependency" (2.53). Thus the vocational agriculture instructors agreed with some agricultural educators who argue that biotechnology is a substitution for the use of chemicals. The teachers' perceptions of the statement "students are interested in learning the biosciences" was neutral to agree with a mean of 3.58. This situation poses a challenge for agriculture instructors and agricultural educators who are working towards developing a new approach to agricultural education.

The oneway analysis of variance showed significant differences among various geographical regions of the country regarding vocational agriculture instructors' perceptions about teaching the biosciences and the role of biotechnology in agriculture (Table 3). The mean scores of only two out of nineteen perception statements were found to be statistically different among various regions. The results of the Tukey test, a post-hoc analysis conducted to compare the mean scores of perceptions among NVATA regions reveals that the mean scores of NVATA region five was found to be greater than region two for the perception statements, "biotechnology can be used to increase yields and cost input" and "biotechnology will be useful for improving disease and insect resistant plant varieties." The mean scores of the statement "biotechnology will help breeders to improve nutritive values of food and feed grains" differed significantly between region one and five.

Data in Table 4 indicate selected correlations between instructors' perceptions on teaching biosciences and demographic factors such as age of respondents, educational attainment, and years of experience. The null hypothesis established was "there exists a significant correlation between demographic factors and perceptions of vocational agriculture instructors." Correlation was analyzed and correlation coefficient 'r' was found to be greater than the probability value (0.05) for six items. This information indicated that six perception statements were positively correlated with the age of the respondents. Out of the six, "learning biosciences would help students to better understand agriculture" was found to have been highly correlated with the age of respondents. It was concluded that as the instructors' age increased their agreement also increased concerning the statement: "learning the biosciences would help students to better understand agriculture."

A correlation analysis between educational qualifications and perception statements revealed both positive and negative results. It was interesting to find that the perception statement "additional

Table 4. Relationship between vocational agriculture instructors' selected perceptions statements and demographic factors

Perception statements	Demographic factors n=237	
	Age	Education
Learning biosciences would help students to better understand agriculture	0.681 [a]	0.165
Learning biosciences would help students in developing skills in the related agriculture fields	0.384	0.225
Students are interested in learning the biosciences as they are related to agriculture	-0.056	0.648
Infusion of the biosciences into vocational agriculture would strengthen FFA activities	0.142	0.434
Bioscience would help in developing SOE programs	0.220	-0.417
Additional instructional materials are required for infusing the biosciences into the study of agriculture	0.034	-0.434
It takes additonal time for the vocational agriculture teacher to incorporate biosciences into the study of agriculture	-0.153	-0.575

[a]Pearson product moment correlation.

instructional materials are required for infusing the biosciences into the study of agriculture" was negatively correlated with educational attainment. As the educational qualifications of instructors increased from B.S. degree to M.S. degree, the instructors' agreement towards the need for additional instructional materials for infusing the biosciences decreased. At the same time, as the instructors' level of education increased from B.S. degree to M.S. degree, they perceived that it would take additional time for bioscience instruction. It was surprising to note that educational qualifications and FFA (Future Farmers of America) were positively correlated while SOEP (Supervised Occupational Experience Program) was negatively correlated with educational qualifications. Of the nineteen perception statements, the following two statements were found to have significant positive correlation with educational attainment: (1) Learning about the biosciences will help students in developing skill in the related agriculture fields, and (2) Students are interested in learning the biosciences as they are related to agriculture.

Analysis of Importance of Bioscience Competencies

One of the objectives of this study was to identify the level to which the bioscience competencies are important as perceived by vocational agriculture instructors in vocational agriculture programs in the U.S.A. Another objective was to compare the degree to which bioscience competencies were important as perceived by vocational agriculture instructors in six regions of the NVATA. Data pertaining to these objectives are organized and presented in Tables 5 to 16.

The mean scores and standard deviations for each of the competencies are presented in rank order in these tables. A one-way analysis of variance was computed in order to compare the perceptions of respondent groups by region. The competencies were grouped into

Table 5. Means and standard deviations for the level of importance of competencies in plant science as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Explain the function of roots	4.37	0.67
Describe the pollination and fertilization	4.26	0.98
Demonstrate the selective action of herbicides	4.17	0.90
Identify important weeds of crop plants	4.15	0.92
Conduct a germination experiment to show the stages of germination of seeds	4.07	1.04
List the limiting factors of plant growth	4.07	0.99
Identify the modes of vegetative propagation in plants	4.05	0.70
Demonstrate the process of uptake of water and nutrients by plants	4.02	1.01
Describe how nitrogen fixation takes place in leguminous crops	3.95	0.99
Demonstrate budding and grafting	3.94	0.98
Demonstrate the foliar application of nutrients in in plants	3.90	0.93
List the ways plants are classified	3.88	0.71
Describe the internal structure of a stem	3.86	0.71
Describe the structure of a flower	3.85	0.98
Demonstrate the practice of hydroponics	3.78	0.92

Table 5. Continued

Competencies	Mean	S.D.
Demonstrate the effect of growth hormone on the rate of vegetatively propagated plants	3.77	1.05
Record through observation the development of a plant	3.77	1.02
Identify some plant growth regulators	3.70	0.99
Explain the formation of fruits	3.65	1.13
Dissect a plant and name the parts	3.63	1.06
Explain the short night and long night plants	3.60	0.80
Identify various modifications of a stem	3.58	0.97
Explain the stock selection in plants	3.45	1.09
Explain the importance of apical meristem in growth	3.37	0.90
Conduct experiment for photosynthesis and respiration in plants	3.35	1.01
Describe the formation of seeds	3.33	0.94
Draw the internal structure of leaves	3.31	1.01
Describe the function of each floral part	3.29	1.14
Grand mean	3.78	

1=Not important
5=Very highly important

Table 6. Means and F-values for the level of importance of selected competency categories in plant science as perceived by vocational agriculture teachers in the U.S.A.

Competency categories	Respondent groups						Mean	F-value
	1	2	3	4	5	6		
		2						
	n=38	n=30	n=39	n=43	n=41	n=26		
Morphology i=7	3.28	3.11	3.35	3.40	3.83	3.29	3.37	1.72
Physiology i=9	3.96	3.47	3.61	3.02	3.81	3.23	3.52	2.89**
Classification i=3	3.46	2.65	3.45	2.86	3.68	3.49	3.27	1.96
Growth & Development i=9	3.14	3.86	4.42	3.14	3.13	3.03	3.45	0.98

** F-value required for significance at 0.01 level of confidence with 5 and 236 of degrees of freedom was 2.65
n= number of respondents in each group
i = number of items in each competency category

categories based on the subject area to which they belong. The Tukey method was used as a post-hoc analysis to identify if significant statistical differences existed among the teachers by the regions with respect to each of the categories.

Of the twenty-eight competencies that were identified in the plant science area, seven competencies had overall mean scores of 4 or higher as expressed on a 1-5 Likert scale. The plant science competency "functions of roots" received the highest mean rating by all six respondent groups with an overall mean of 4.37 and "process of pollination and fertilization" (4.26) was ranked second by the respondents. It was observed that the lowest ranking was given to the competencies "formation of seeds" (3.33) and "function of floral parts" (3.29). It was also found that the vocational agriculture instructors in various regions of the country differed significantly in their perceptions with respect to the competencies that dealt with the category "plant physiology." To summarize, the grand mean for the plant science area that are important was found to be 3.78 (Table 5). The mean scores of competencies related to plant physiology in region one are significantly higher than region four (Table 6).

The area of genetics consisted of twenty-five items. The vocational agriculture instructors rated "list various plant breeding techniques" with a mean of 4.62 as the highest rated competency perceived to be important (Table 7). The second and third items were "distinguish between plant and animal cell" (4.23) and "list the criteria for selecting breeding stock" (4.11). It was clear from this information that the competencies classified under biotechnology such as "discuss the process of tissue culture" (2.87) and "explain the formation of recombinant DNA" (2.61) were given the lowest rating regarding the level of importance in these areas.

Table 8 shows the results of the Tukey test, a post-hoc analysis to determine if significant differences existed among the agriculture instructors of various regions of the country regarding the level of importance in the area of genetics. The mean scores of the region two were significantly lower than region five for the genetics competencies that related to biotechnology such as "process of tissue culture", "cloning of genes", and "role of monoclonal antibodies for pregnancy testing." Significant differences between regions three and five were also observed

Table 7. Means and standard deviations for the level of importance of competencies in genetics as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
List various plant breeding techniques	4.62	0.98
Distinguish between plant and animal cell	4.23	0.95
List the criteria for selecting breeding stock	4.11	0.99
Explain the principle of developing plant and animal disease resistant varieties	4.10	0.97
List the method of breeding swine	4.00	1.04
Distinguish between in-breeding and out-breeding in animals	3.54	0.98
Explain the process of embryo transfer	3.48	1.10
State the Mendel's law of inheritance	3.47	1.12
Draw a plant and an animal cell	3.31	1.04
Describe the function of DNA	3.26	0.92
Describe the cloning of genes	3.17	1.24
Enumerate the differences between traditional plant breeding methods and gene splicing	3.09	1.15
Describe the process of natural selection in plants	3.06	1.04
Explain the process of gene splicing	3.30	0.86
Describe how mutation takes place in plants	2.91	1.12

Table 7 Continued

Competencies	Mean	S.D.
Discuss the process of tissue culture	2.87	1.26
Explain the process gene insertion into germ cell lines	2.63	1.20
Explain the formation of recombinant DNA	2.61	1.18
Explain the process of transgenesis	2.54	1.17
Grand mean	3.02	

1= Not important
5= Very highly important

for competencies concerned with plant breeding. In summary, the grand mean for all the NVATA regions for the area of genetics with respect to competencies that are found to be important was 3.02.

Out of seventeen competencies in the area of animal science, it was found that seven competencies were rated highly regarding the level of importance being given in these areas. The top two competencies were: "demonstrate the procedure of artificial insemination" (4.07) and "describe the symptoms of major animal diseases" (4.03). The competencies dealing with physiological processes such as "function of endocrines in animals" (3.06) and "physiology of lactation, egg production in animals" (2.69) received the lowest rating (Table 9). The

Table 8. Means and F-values for the level of importance of selected competency categories in genetics as perceived by vocational agriculture teachers in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=30	n=39	n=43	n=41	n=26		
Cell biology i=4	3.59	3.13	3.34	2.98	4.02	3.06	3.35	1.89
Plant breeding i=9	4.18	3.83	3.91	4.02	4.31	2.78	3.83	3.02**
Biotechnology i=12	3.11	2.83	3.05	3.28	4.00	3.44	3.28	2.75**

** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65
n=Number of respondents in each group
i =Number items in each competency category

mean scores of region five were significantly higher than region one for the categories, animal systems and technology for growth.
In summary, the grand mean for the animal science area with respect to the level importance of the competencies was 3.41 (Table 9).

Twenty-three competency statements constituted the area of soil science. Data in Table 11 show that fifteen items were rated a mean of 4.00 or higher. The highest rated items were: "demonstrate the methods of maintaining water quality" (4.67), "explain soil alkalinity,

Table 9. Means and standard deviations for the level of importance of competencies in animal science as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Demonstrate the procedure of artificial insemination	4.07	1.02
Describe the symptoms of major animal diseases	4.03	1.02
List the factors for selection of animal breeds	3.99	1.04
Demonstrate the use of vaccines in selected animals	3.99	0.98
Explain the principle of immunization in animals	3.98	1.06
Identify the classification of livestock species	3.86	1.10
Describe the reproductive system of selected animals	3.83	1.10
Calculate balanced feed ration	3.81	1.15
Outline the procedures to control animal diseases	3.80	1.06
Describe the composition of meat and milk	3.79	1.15
Analyze the ingredients of selected animal products	3.78	1.14
Explain how cycling time can be increased in animal production	3.54	1.03
Describe the principles of sex linkage in animals	3.12	0.96

Table 9. Continued

Competencies	Mean	S.D.
Explain the function of endocrines in animals	3.06	1.14
Draw the digestive system of ruminant animals	2.99	1.11
Explain the role of bovine growth hormone in milk production	2.74	1.16
Explain the physiology of lactation and egg production in animals	2.69	0.96
Grand mean	3.41	

1= Not important
5= Very highly important

salinity and acidity" (4.13), and "demonstrate how to take soil sample and interpret soil test results" (4.09). The soil science competencies "demonstrate cation exchange capacity of soil" (3.88) and "measure electrical conductivity of soil" (3.84) received the lowest ratings.

The mean scores of region three was significantly higher than regions one and two for the category of "soil water." In summary, the grand mean value for soil science competencies regarding the level at which they are important was found to be 4.14.

Table 10. Means and F-values for the level of importance of selected competency categories in animal science as perceived by vocational agriculture teachers in the U.S.A.

Competency categories (N)	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=30	n=39	n=43	n=41	n=26		
Animal systems n=4	3.29	3.66	3.88	3.20	4.02	3.70	3.62	3.47**
Diseases & control i=4	3.70	4.00	3.77	4.28	4.19	4.22	4.03	1.62
Feeds & Feeding i=2	3.29	3.88	3.94	4.31	4.16	4.11	3.95	1.03
Animal products i=3	3.18	3.36	3.51	3.45	3.94	3.74	3.53	0.98
Technology i=4	3.74	3.91	3.88	4.42	4.16	4.03	3.03	6.21**

** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65

n= Number of respondents in each group

i = Number of items in each competency category

Table 11. Means and standard deviations for the level of importance of competencies in soil science as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Describe the nature and properties of soil	4.41	0.75
Demonstrate the methods of soil conservation	4.39	0.71
List the macro and micro nutrients of soil	4.38	0.76
Distinguish between conventional tillage and conservation tillage	4.31	0.89
Explain soil erosion control measures	4.30	0.83
Analyze an on-site soil profile to illustrate types of soil	4.28	0.74
Distinguish between soil texture and structure	4.28	0.77
Determine soil water availability	4.25	0.81
Explain soil compaction	4.23	0.81
Explain soil alkalinity, salinity and acidity	4.21	0.85
Demonstrate the methods of maintaining water quality	4.29	0.86
List the environmental factors contributing to soil erosion	4.14	0.81
Explain the biological properties of soil	4.13	0.86

Table 11. Continued

Competencies	Mean	S.D.
Demonstrate water holding capacity of soil	4.08	0.85
Describe the importance of soil organic matter	4.03	0.84
Describe the principle of organic farming	3.99	0.94
Demonstrate how to take soil sample and interpret soil test results	3.98	0.89
Describe soil formation	3.94	0.82
Develop pH scale to plot acidity and alkalinity	3.93	0.90
Describe the cycle of soil ecosystem	3.91	0.90
Demonstrate cation exchange capacity of soil	3.88	0.90
Measure electrical conductivity of soil	3.84	0.97
Grand mean	4.14	

1= Not important
5= Very highly important

Table 12. Means and F-values for the level of importance of selected competency categories in soil science as perceived by vocational agriculture teachers in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Nature & properties i=9	4.25	4.02	4.51	4.47	4.70	4.41	4.39	1.08
Soil nutrients i=4	4.40	4.09	4.34	4.40	4.17	4.72	4.35	0.88
Problem soils i=6	3.63	3.61	4.37	4.60	4.83	4.66	4.28	7.05**
Soil water i=4	3.70	3.58	4.83	4.37	4.31	4.33	4.18	1.78

** F-value required for significance at 0.01 level of confidence with 5 and 231 degrees of freedom was 2.65
n= Number of respondents in each group
i = Number of items in each competency category

function of microorganisms received the lowest mean score (2.79). Same differences existed among the various regions with respect to the importance in the area of microbiology (Table 14). The mean scores of agriculture instructors in the region five were significantly higher than regions two and three for the competencies related to the structure and function of microorganisms such as "structure of algae", structure of

Table 13. Means and standard deviations for the level of importance of competencies in microbiology as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Identify nitrogen fixing organisms and explain how they fix nitrogen	3.86	0.93
Identify the symptoms of major diseases of agronomic plants	3.85	0.89
List beneficial microbes in agriculture	3.74	0.95
Distinguish between fungi and bacteria related to agriculture	3.60	0.88
Demonstrate the operation of the compound microscope and its relationship to agricultural science	3.47	0.94
Describe the ways of classifying microorganisms related to agriculture	3.45	0.88
Demonstrate culturing of microorganisms in the laboratory	3.39	0.96
Observe the structure and composition of a bacterial cell under the microscope	3.24	1.08
Identify the differences between autotropic and heterotropic microbes	3.20	0.98
Explain reproduction fungi	3.11	0.98
Draw the structure of algae	2.96	0.94
Draw the structure of a selected fungus in agriculture	2.87	1.26

Table 13. Continued

Competencies	Mean	S.D.
Draw the structure of yeast	2.79	1.76
Grand mean	2.87	

1= Not important
5= Very highly important

fungi", "reproduction in fungi", and "difference between autotropic and heterotropic bacteria." The grand mean for competencies in the area of microbiology that are found to be important was 2.87.

The area of food science consisted of nineteen competency items. None of the items was ranked "highly important." The highest ranking was given to "explain the processing of milk and dairy products" (3.86), followed by "describe the various methods of processing fruits and vegetables" (3.77). The competency "the microbial process that takes place during the preparation of bread" (2.86) was given the lowest importance in vocational agriculture programs (Table 15).

The mean scores of region five were significantly higher than regions one, two, three, and four for the competencies concerned with the category "food spoilage." The mean scores of region six were significantly higher than regions one and two for the food science competencies

Table 14. Means and F-values for the level of importance of selected competency categories in microbiology as perceived by vocational agriculture teachers in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Identification of microbes i=3	3.29	3.11	3.84	2.67	3.02	2.89	3.13	1.92
Structure of microbes i=6	2.74	2.77	2.84	3.20	3.18	3.25	2.99	3.72**
Role of microbes i=3	3.70	3.58	2.91	2.81	3.19	3.85	3.34	1.72
Culturing microbes i=1	2.40	2.61	2.91	2.97	3.91	3.00	2.96	1.44

** F-value required for significance at 0.01 level of confidence with 5 and 231 degrees of freedom was 2.65.
n= Number of respondents in each group
i= Number of items in each competency category

Table 15. Means and standard deviations for the level of importance of competencies in food science as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Explain the processing of milk and dairy products	3.86	0.97
Describe the various methods of processing fruits and vegetables	3.77	1.01
List the fungi used in the manufacture of cheese	3.73	1.24
Identify various food preservatives	3.72	1.16
Explain the concept of food chain	3.70	1.05
Describe pasteurization of milk	3.68	1.01
Describe the importance of yeast to man	3.66	1.11
Identify wholesale and retail cuts of meat	3.65	1.03
Explain the role of barley malt as a flavor supplement in baking industry	3.61	0.98
Describe how vinegar is used in the manufacture canned vegetables	3.59	1.11
Describe the process of milk formation in cattle	3.52	1.10
Describe the process of fermentation	3.51	1.00
Demonstrate the laboratory preparation of vinegar	3.50	1.01
Identify the food that spoil fruits and vegetables	3.36	1.12

Table 15 Continued

Competencies	Mean	S.D.
Explain the process of conversion of feed in hogs and cattle	3.29	1.14
Explain how nutritive value of food in feed grains can be improved	3.13	0.93
Identify artificial sweeteners that can be manufactured in their industry using biotechnology	2.94	1.17
Explain the microbial activity in milk and how it helps in the formation of milk products	2.91	1.24
Explain the microbial process that takes place during the preparation of bread	2.86	1.17
Grand mean	3.58	

1= Not important
5= Very highly important

Table 16. Means and F-values for the level of importance of selected competency categories in food science as perceived by vocational agriculture teachers in the U.S.A.

Competency categories	Respondent groups						Mean	F-value
	1 N=38	2 N=50	3 N=39	4 N=43	5 N=41	6 N=26		
Food spoilage i=4	3.18	3.05	3.34	3.60	4.01	3.59	3.46	3.97**
Food preservatives i=5	3.44	3.85	3.61	4.31	4.44	3.85	3.96	2.39*
Food processing i=10	3.44	3.25	3.37	3.77	3.02	3.55	4.10	3.33**

* F-value required for significance at 0.05 level of confidence with 5 and 231 degrees of freedom was 1.99

** F-value required for significance at 0.01 level of confidence with 5 and 231 degrees of freedom was 2.65

n=number of respondents in each group

i =number of items in each competency category

Analysis of Expansion of Instruction of Bioscience Competencies

The second objective of this study was to determine the extent to which instruction in selected bioscience competencies would be increased given materials and inservice as perceived by vocational agriculture instructors. Data pertaining to this objective are organised and presented in Tables 17 to 28.

The instructors indicated a need to expand instruction in eleven competencies in the area of plant science. The three competencies which received the highest overall mean ratings in this area were: "describe the process of pollination and fertilization" (4.38), "demonstrate the practice of hydroponics" (4.22), and "describe the formation of seeds" (4.20) (Table 17). The grand mean for the plant science area as a whole was 4.21. Table 18 indicates that significant differences regarding the degree to which instruction in selected competencies should be expanded in the area of plant science. The ratings for the competency category "growth and development" was significantly lower in region one than regions five and six.

The vocational agriculture instructors ranked the competency "list the methods of breeding in swine" (4.36) as the number one instructional need in the area of genetics. The mean scores for the competency "list the criteria for selecting breeding stock" (4.29) and "describe the role of gene splicing in the production of porcine and bovine somatotropin" (4.27) were ranked second and third (Table.19). The grand mean score regarding the expansion of instruction in the genetics area as perceived by vocational agriculture instructors was 4.11.

Significant differences between various regions of instruction in selected competencies in the area of genetics is shown in Table 20. The mean scores of region six were found to be significantly higher than region two for the category of "cell biology." It was observed that the

Table 17. Means and standard deviations for the degree to which instruction would be expanded in plant science competencies as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Describe the process of pollination and fertilization	4.38	0.98
Demonstrate the practice of hydroponics	4.25	1.08
Describe the formation of seeds	4.20	0.99
List the limiting factors of plant growth	4.18	0.84
Describe how nitrogen fixation takes place in leguminous crops	4.16	0.99
Describe the function of each floral part	4.14	0.70
Demonstrate the selective action of herbicides	4.11	0.87
Identify the modes of vegetative propagation in plants	4.07	0.83
Dissect a plant and name its parts	4.05	1.13
Demonstrate the process of uptake of water and nutrients by plants	4.02	1.01
Identify important weeds of crop plants	3.98	0.94
Demonstrate the foliar application of nutrients in plants	3.96	0.93
Demonstrate budding and grafting	3.92	0.90
Explain the formation of fruits	3.91	0.87
Identify various modifications of a stem	3.90	1.14

Table 17. Continued

Competencies	Mean	S.D.
Explain the stock selection in plants	3.86	0.97
Conduct experiment for photosynthesis and respiration in plants	3.84	1.03
Demonstrate the effect of growth hormone on the rate of vegetatively propagated plants	3.82	0.92
Describe the structure of a flower	3.80	0.98
Conduct a germination experiment to show the stages of germination of seeds	3.79	1.00
Identify some growth regulators	3.77	1.05
Describe the internal structure of a stem	3.69	0.87
Record through observation the development of a plant	3.62	1.05
List the ways plants are classified	3.57	0.94
Draw the internal structure of leaves	2.96	0.94
Explain the short night and long night plants	2.83	1.06
Explain the importance of apical meristem in growth	2.79	1.09
Grand mean	4.21	

1= Not important
5= Very highly important

Table 18. Means and F-values for the degree to which instruction would be expanded in selected plant science competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Morphology i=7	3.32	3.36	3.85	3.65	4.27	3.74	3.69	1.67
Physiology i=9	3.71	3.83	3.91	4.28	4.30	4.07	4.01	1.72
Classification i=3	3.17	3.38	3.74	4.13	3.59	4.13	3.69	0.89
Growth & Development i=9	2.85	4.19	4.41	4.60	4.86	4.59	4.25	3.25**

** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65
n=Number of respondents in each group
i =Number of items in each competency category

regions did not significantly differ with respect to categories such as "biotechnology" and "plant breeding." This is an indication that the vocational agriculture instructors are interested in expanding their instruction in some areas of biotechnology but not at the cellular level.

Table 19. Means and standard deviations for the degree to which the instruction would be expanded in genetics competencies as perceived by instructors of agriculture in U.S.A. (n=237)

Competencies	Mean	S.D.
List the methods of breeding in swine	4.36	0.75
List the criteria for selecting breeding stock	4.29	0.77
Describe the role of porcine somatotropin in the production of pork	4.27	0.74
List various plant breeding techniques	4.14	0.82
Describe the cloning of genes	4.11	1.12
Describe the process of tissue culture	4.09	0.99
Distinguish between in-breeding and out-breeding in animals	4.08	0.80
Explain the process of embryo transfer	4.06	0.95
Explain the principle of developing pest and diseases resistant crop varieties	3.88	0.88
Explain the role of monoclonal antibodies for pregnancy testing	3.86	0.92
Explain the formation of recombinant DNA	3.85	0.97
Explain the process of gene splicing	3.82	1.04
Enumerate the difference between traditional plant breeding methods and and gene splicing	3.81	0.92
Describe the structure and function of DNA	3.81	0.92

Table 19. Continued

Competencies	Mean	S.D.
Draw a plant cell and an animal cell	3.78	0.96
Explain the advantages of crop improvement	3.77	0.91
State Mendel's law of inheritance	3.76	1.01
Distinguish between plant cell and animal cell	3.73	1.05
Describe the advantages of gene splicing over the traditional plant breeding methods	3.71	1.12
Describe the process of natural selection of plants	3.69	1.09
Take a cross section of a plant part and observe through the microscope	3.43	1.02
Describe how mutation takes place in plants	3.12	1.27
Describe gene expression	2.96	1.18
Explain the process of transgenesis	2.87	1.24
Explain the process of gene insertion into germ cell lines	2.72	1.07
Grand mean	4.11	

1= Not important
5= Very highly important

Table 20. Means and F-values for the degree to which instruction would be expanded in selected genetics competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Cell biology i=4	3.25	3.32	3.11	3.65	4.44	3.26	3.50	6.39**
Plant breeding i=9	3.40	3.94	3.88	4.40	4.41	4.22	4.04	1.97
Biotechnology i=12	3.51	4.36	4.43	3.68	4.63	3.86	4.08	1.69

** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65
n=Number of respondents in each group
i =Number of items in each competency category

Outline the procedures to control animal diseases" received a high mean rating of 4.37, which was the highest rated item in the animal science area. The competency statement "list the factors for selection of animal breeds" was ranked second with a mean of 4.32. The animal science competencies, "explain the physiology of lactation, egg production in animals" (2.89) and "describe the composition of meat and milk" (2.87) were ranked the lowest (Table 21). The grand mean score for the animal science area as a whole was 4.32. The vocational

Table 21. Means and standard deviations for the degree to which instruction would be expanded in animal science competencies as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Outline the procedures to control animal diseases	4.37	1.15
List the factors for selection of animal breeds	4.32	1.26
Calculate balanced feed ration	4.32	0.96
Describe the symptoms of major animal diseases	4.25	0.79
Explain the principle of immunization in animals	4.22	1.04
Demonstrate the procedure of artificial insemination	4.14	1.02
Demonstrate the use of vaccines in selected animals	4.01	1.06
Explain the role of bovine growth hormone in milk production	3.98	1.74
Identify the classification of livestock species	3.92	0.91
Explain how cycling time can be increased in animal production	3.86	1.11
Describe the reproductive system of selected animals	3.79	1.15
Draw the digestive system of ruminant animals	3.77	1.04

Table 21. Continued

Competencies	Mean	S.D.
Explain the function of endocrines in animals	3.67	1.09
Analyze the ingredients of selected animal products	3.44	0.96
Explain the physiology of lactation, egg production in animals	2.89	1.10
Describe the composition of meat and milk	2.87	1.03
Describe the principles of sex linkage in animals	2.48	1.06
Grand mean	4.32	

1= Not important
5= Very highly important

agriculture instructors in different regions did not vary significantly with respect to the expansion of competencies in the animal science area (Table 22).

Six soil science competencies received high mean ratings regarding expanding instruction (Table 23) . The highest rated items were "explain soil alkalinity, salinity, and acidity" (4.67) followed by "demonstrate the methods of maintaining water quality" (4.13) and "demonstrate how to take soil samples and interpret soil test results" (4.09). The composite mean for the soil science area was 3.87. Significant differences existed between regions one and three with regard to expansion of instruction in the category of "soil water" (Table 24).

Table 22. Means and F-values for the degree to which instruction would be expanded in selected animal science competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Animal systems i=4	3.45	4.00	4.12	3.86	4.33	3.98	3.96	2.17*
Diseases & control i=4	4.22	4.30	4.11	4.45	4.69	4.37	4.36	1.89
Feeds & Feeding i=2	4.07	4.22	4.31	4.40	4.44	3.87	4.22	1.23
Animal products i=3	3.29	3.38	3.60	3.68	4.41	3.81	3.69	1.57
Technology i=4	3.92	4.27	4.31	4.42	4.61	4.40	4.32	0.89

* F-value required for significance at 0.05 level of confidence with 5 and 236 degrees of freedom was 1.99
n=Number of respondents in each group
i =Number of items in each competency category

Table 23. Means and standard deviations for the degree to which instruction would be expanded in soil science competencies as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Explain soil alkalinity, salinity and acidity	4.67	1.07
Demonstrate the methods of maintaining water quality	4.13	1.01
Demonstrate how to take soil sample and interpret soil test results	4.09	0.99
Demonstrate the methods of soil conservation	4.08	1.03
List the environmental factors contributing to soil erosion	4.06	0.87
Explain soil erosion control measures	4.03	1.09
Analyze an on-site soil profile to illustrate types of soil	3.99	1.05
Distinguish between conservation tillage and conventional tillage	3.97	1.10
Describe the importance of soil organic matter	3.96	1.09
Distinguish between soil texture and structure	3.93	1.13
List the macro and micro nutrients of soil	3.89	0.97
Explain soil compaction	3.85	1.10

Table 23. Continued

Competencies	Mean	S.D.
Explain the biological properties of soil	3.84	1.08
Demonstrate water holding capacity of soil	3.83	1.12
Determine soil water availability	3.73	1.12
Identify pH ranges for major crops	3.69	1.11
Describe the cycle of soil ecosystem	3.68	1.11
Develop pH scale to plot acidity and alkalinity	3.67	1.15
Describe soil formation	3.65	1.13
Describe the principle of organic farming	3.61	1.08
Demonstrate cation exchange capacity of soil	3.57	1.10
Measure the electrical conductivity of soil	3.34	1.09
Describe the nature and properties of soil	3.12	0.94
Grand mean	3.87	

1= Not important
5= Very highly important

Table 24. Means and F-values for the degree to which instruction would be expanded in selected soil science competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Nature & properties i=9	4.74	3.61	3.14	4.42	4.16	4.14	4.03	2.25*
Soil nutrients i=4	3.59	3.50	3.82	4.22	4.08	4.00	3.86	1.77
Problem soils i=6	3.63	3.61	3.85	4.37	4.30	3.92	3.95	1.22
Soil water i=4	4.00	3.91	4.05	4.42	4.39	4.02	4.13	1.54

* F-value required for significance at 0.05 level of confidence with 5 and 236 degrees of freedom was 1.99
n=Number of respondents in each group
i =Number of items in each competency category

Table 25. Means and standard deviations for the degree to which instruction would be expanded in microbiology competencies as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Identify nitrogen fixing organisms and explain how they fix nitrogen	3.85	1.05
Identify symptoms of major diseases of agronomic plants	3.84	1.09
List beneficial microbes in agriculture	3.78	1.07
Distinguish between fungi and bacteria related to agriculture	3.51	1.05
Demonstrate the operation of the compound microscope and its relationship to agriculture	3.37	1.06
Demonstrate the ways of classifying micro-organisms related to agriculture	3.28	1.10
Demonstrate the culturing of micro-organisms in the laboratory	3.16	1.17
Observe the structure and composition of a bacterial cell under the microscope	3.09	0.94
Identify the difference between autotropic and heterotropic microbes	3.08	0.68
Explain reproduction in fungi	3.02	1.11
Draw the structure of algae	2.92	1.01
Draw the structure of selected fungus	2.67	0.86

Table 25. Continued

Competencies	Mean	S.D.
Draw the structure of yeast	2.80	1.13
Grand mean	3.16	

1= Not important
5= Very highly important

Table 26. Means and F-values for the degree to which instruction would be expanded in selected microbiology competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups						Mean	F-value
	1	2	3	4	5	6		
	n=38	n=50	n=39	n=43	n=41	n=26		
Identification of microbes i=3	3.07	3.05	3.80	3.68	3.79	3.58	3.49	1.31
Structure of microbes i=6	2.88	2.58	3.17	3.22	3.55	3.11	3.08	3.17**
Role of microbes i=3	3.66	3.27	3.82	3.68	3.87	4.03	3.72	1.89
Culturing microbes i=1	3.40	2.86	2.44	3.25	3.21	3.54	3.12	0.87

** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65

n=Number of respondents in each group

i =Number of items in each competency category

Table 27. Means and standard deviations for the degree to which instruction would be expanded in food science competencies as perceived by vocational agriculture teachers in the U.S.A. (n=237)

Competencies	Mean	S.D.
Describe the process of fermentation	4.47	0.66
Identify wholesale and retail cuts of meat	4.24	0.86
Identify some artificial sweeteners that can be manufactured in the industry using biotechnology	4.12	0.92
Explain the processing of milk and dairy products	4.04	0.80
Describe the various methods of processing of fruits and vegetables	4.01	0.80
Describe the process of milk formation in cattle	3.99	0.86
Explain the concept of food chain	3.99	0.82
Explain the process of conversion of feed into meat in hogs and cattle	3.98	0.84
Describe pasteurization of milk	3.93	0.77
Explain how nutritive value of food can be improved	3.80	0.95
Explain the microbial activity in milk and how it help in the formation of milk products	3.78	0.87
Describe how vinegar is used in the manufacture of canned vegetables	3.63	0.87

Table 27. Continued

Competencies	Mean	S.D.
Explain the role of barley and malt as a flavor supplement in baking	3.30	0.93
Grand mean	3.76	

1= Not important
5= Very highly important

Table 25 indicates that most items rated low in the area of microbiology. The competency "identify nitrogen fixing organisms and explain how they fix nitrogen" (3.85) was the highest ranked item in this competency area. The lowest rated competency was "structure of yeast" with a mean of 2.40. The composite mean for the microbiology area was 3.16. It was observed that the mean scores for the regions which differed significantly regarding the importance of competencies differed significantly regarding the expansion of instruction in this area (Table 26).

Table 28. Means and F-values for the degree to which the instruction would be expanded in selected food science competency categories as perceived by agriculture teachers in various regions in the U.S.A.

Competency categories	Respondent groups 1	2	3	4	5	6	Mean	F-value
	n=38	n=50	n=39	n=43	n=41	n=26		
Food spoilage i=4	3.29	3.25	3.42	3.57	4.25	3.63	3.56	2.23*
Food preservatives i=5	3.25	3.42	3.86	3.88	4.16	3.92	3.74	2.10*
Food processing i=10	3.51	4.10	4.17	4.12	4.33	3.96	4.03	4.03**

* F-value required for significance at 0.05 level of confidence with 5 and 236 degrees of freedom was 1.99
** F-value required for significance at 0.01 level of confidence with 5 and 236 degrees of freedom was 2.65
n=Number of respondents in each groups
i =Number of items in each competency category

In the food science area four out of nineteen items received high ranking regarding expansion of instruction (Table 27). The competency statements "describe the process of fermentation" (4.47), "explain processing of milk and dairy products" (4.24), and "identify some artificial sweeteners that can be manufactured in the industry using biotechnology" (4.12) was the order of priorities perceived by the vocational agriculture instructors regarding expansion of instruction in this area. The grand mean for expansion of instruction in the food science area was 3.76. The mean scores of region five were significantly greater than region three for the competencies falling under the category food preservatives and food processing (Table 28).

Open Comments of the Respondents

The respondents wrote several comments on the questionnaires. The following lists are the comments presented by respondents by the NVATA regions

Region I

1. I would like to know the results of this survey. Late spring is a bad time for a teachers' survey. Winter would be better.
2. We must be reminded that each student has different needs. I don't think Vo.Ag. programs should get so heavily involved with bioscience that they may lose of the objectives of vocational education.
3. Lengthy questionnaire, but good. I really thought these questions were common sense.
4. This is what is needed in Ag. science. My hats off to you.

Region II

5. Biotechnology is in my opinion, the feeding and clothing our world with a reduction in chemical dependence.
6. Agriculture is and always has been bioscience.
7. If too much bioscience is incorporated into high school, students aren't going to be able to experience all areas of agriculture.
8. Students will not learn or attempt to learn more bioscience if they are involved in farming or see a real need for this type of education.
9. Iam interested in the results of this survey.
10. Having been involved in a study while completing my master's I found it very frustrating when the university took no action on

the recommendation from the study. It is time they either take time to teach high school again or revise what they are teaching in college.

11. I am interested in the food science questions. Food science would perhaps expand the view the public has on agriculture. Every one has to eat!

Region III

12. I think we must move ahead with biotechnology. Our agriculture education must change to meet the needs.
13. Agriculture is a science and bioscience a part of it. Needs more emphasis as a part of modern agriculture.
14. The teachers cannot handle biosciences without relevant materials.
15. A long but detailed survey.
16. Please send survey results to me.

Region-IV

17. I found that I really wanted to add much of the materials to my curriculum. However as I entered the microbiology section and continued through the survey I found myself questioning how practical or is it going to be possible to add these subjects to my curriculum without major redirections in my studies requiring additional time at the university level. Secondly, by going in the direction of more academic materials for our students are we forgetting students who are not going on towards higher education. I am questioning my abilities to teach all things to all students just to keep my numbers up so that I can keep my job up.
18. Without instructional materials and proper guidance for teachers, this program would face severe problems.

19. The incorporation of bioscience would be a good for a select few but the majority of my students couldn't handle the material.
20. This sounds good. Get us the text book on "Bioscience."

Region V

21. The survey is too long.
22. I feel like I am spinning my own wheels, I would like to teach more Ag. Sciences. But I don't know what to use, how to do it, or how comfortable I will be with the teaching materials.
23. Many of the questions asked are "taken care of" by the science department of our school.
24. Hands on experience activities on biosciences would be much more useful.
25. There is a thin line between science for credit and as an elective. This is great for some students, but not all can handle the material. Last year some of my students were classified as "untrainable." Teaching this subject material with good guidance can help a program, with poor guidance it can destroy it. Rating these can vary depending on which group of students you rate for.
26. Teachers would need a lot of inservice training with bioscience program in high schools.
27. I would like to receive a copy of this report when my area of study is completed.
28. Only few of the high school students I teach are capable of much of the work you outlined above (5% -10%).

Region VI

29. It is hard to try and teach what we need, to let alone add anything else.

30. A number of competencies are important but are already being taught in the program. I feel some are a bit complex for high school students. I believe in basics. We can build from a good foundation.
31. In Pennsylvania, we are beginning a study this summer on how we can introduce agriscience into our Vo.Ag. programs. We are trying to get away from cows and ploughs.
32. Yes, it should be incorporated into the ag. programs but at the most advanced level. But it would require a lot of additional cost to operate the programs which is always a problem.
33. The reason I may have a '5' for importance and '3' for expansion is that I am aware that materials are already available to me and I would not expand much.

Summary

The following statements summarize the major findings of this investigation:

1. The composite average age of vocational agriculture instructors of the U.S.A. was found to be 44.4 years. Among the respondents, 47.3 percent of the instructors possessed a bachelor of science degree while 52.7 percent earned a master of science degree. The average experience of the agriculture instructors was observed to be 14.7 years.
2. Respondents agreed most on the statement that "additional instructional materials are required for infusing the biosciences." Respondents also disagreed that "biotechnology will promote chemical dependency."
3. The respondents perceived that "learning the biosciences would help students to better understand agriculture." At the same time, the respondents did not totally agree with the statement "students are interested in learning the biosciences as they are related to agriculture."

4. A oneway analysis of variance and a Tukey test revealed significant statistical differences for only two out of fourteen perception statements regarding teaching the biosciences.
5. It was found that as the instructors' age increased their agreement also increased concerning the statement , "learning biosciences would help students to better understand agriculture". It was found to have a significant positive correlation with the age of respondents.
6. While analyzing the bioscience competencies, the agriculture instructors ranked the competencies listed in the soil science area as the competencies that were highly important. The microbiology competencies were given lowest importance.
7. While analyzing the bioscience competencies, the agriculture instructors ranked the competencies listed in the soil science area as the competencies that were highly important The microbiology competencies were given lowest importance.
8. Instructors wanted to expand instruction in the competencies listed in the animal science area to the greatest extent but did not see microbiology competencies being expanded to any great extent.
9. The respondents varied in their responses by region. The respondents in region five consistently perceived the bioscience competencies that are important to a greater extent than the respondents in the regions two and one.

CHAPTER V. DISCUSSION

The primary purpose of this study was to identify the level to which selected bioscience competencies were important to the study of agriculture and also to identify the extent to which instruction in these competencies would be increased given materials and inservice education as perceived by the vocational agriculture instructors in the U.S.A. In addition, the study sought to determine the perceptions held by vocational agriculture instructors regarding teaching the biosciences, and to compare the various groups of respondents regarding their perceptions on selected bioscience competencies and demographic factors.

While interpreting the findings of the study, the following characteristics in the design of the study should be considered:

1. A pilot test of the instrument was conducted. The pilot test helped to identify the problem areas in the instrument such as interpretation of correct meaning and ease of understanding. The pilot test also helped to reduce the length of the questionnaire by fifteen questions.
2. The expert committee represented by the members of the Iowa Technical Committee on Biotechnology and vocational agriculture instructors who established the content validity of the instrument provided a major strength of this project.
3. The final response rate of this survey was 47.3 percent. Had this survey been conducted in early spring or late fall, the final return rate might have been higher. In addition, further reduction of the length of the questionnaire might have increased the response rate. If the respondents had been asked to encircle the numbers in the scale from 1 to 5,

we might have increased the response rate, instead of asking them to write the numbers every time to express their perceptions regarding the competency statements. However, when one considers the usable sample size (237), the nation-wide coverage of this survey, the representation to all fifty states in the survey, and the wide range of the biosciences covered by the survey, it can be concluded that forty-seven percent was a reasonable response rate. Another strength of this survey was that, there were no significant statistical differences between the mean scores of the respondents who completed and mailed the questionnaire and the non-respondents who were later contacted by telephone. It was understood from the non-respondents that a lack of time and the length of the questionnaire had posed certain limitations on them.

4. The reliability of the instrument was adequate.
5. The national scope of the study was a significant aspect of this research effort since the findings of the research study could be generalized to the entire country.
6. Stratified random samples were drawn from the six NVATA regions of the country. As NVATA communications are initiated and maintained through the national office to the regions, it is assumed that the data pertinent to the respective regions would be beneficial for further projects such as development of instructional materials and inservice educational programs to teachers, etc.

One of the objectives of this study was to determine the perceptions of vocational agriculture instructors regarding teaching the biosciences. Overall, the agriculture instructors agreed with the statement, "learning the biosciences would help students understand agriculture." This finding indicated that the instructors were aware of the fact that the study of agriculture needs basic knowledge of the biosciences. This premise is also supported by the statement that the biosciences place increased emphasis on broadening students' knowledge of basic agricultural functions and systems (Martin, 1987). It can be concluded that the instructors have agreed with the point that fundamental aspects of the biosciences would help students to better understand agriculture.

The agriculture instructors also agreed with the statement that the students should learn how to explain the processes that occur in plants and animals while studying agriculture. This finding seems somewhat contradictory to the philosophy of the vocational agriculture education which states, "vocational agriculture education programs are aimed at preparing individuals for entrepreneurship or employment" (Buriak, 1989). Obviously, certain fundamental principles or process-oriented instruction is necessary for entrepreneurship or occupational education. Students need to know how and why agricultural systems work.

The statement, "infusion of more of the biosciences would expose students to diversified career opportunities in the field of biotechnology" received a neutral score from agriculture instructors. The researcher suspected that some instructors agreed with the statement because of the fact that they were in the process of gaining knowledge about the growing employment opportunities in the field of agriculture related to the sciences. At the same time, some instructors disagreed with the statement because of unrealistic views of employment opportunities available in agriculture. Martin (1988a`) also supported the investigator's contention that current vocational agriculture programs may fail to alert students regarding new career opportunities in agriculture especially those related to biotechnology.

The instructors agreed with the statement, "learning about the biosciences helps students in developing skills in related agriculture fields." This information indicates that the instructors are aware of the "skills" related to the biosciences. The need for skill development was also emphasized by Sutphin (1985) when he stated that the biological sciences offer special opportunities for students to understand specific technological skills such as animal reproduction, which in turn can result in enormous gains in production efficiency. It can be concluded that the instructors were becoming aware of the role of science in a successful agriculture program.

There exists a perception among some agriculture instructors that vocational agriculture students are not very interested in learning the biosciences related to agriculture. This finding might be attributed to the fact that the instructors were concerned that too much focus on the sciences of agriculture may hurt enrollment instead of enhance enrollment in agriculture programs. However, certain instances indicate that motivating the desire of students toward learning the principles and practices of the biosciences of agriculture greatly depends on the performance of the teacher. Perry (1989) supported these views when she stated that student interest would be piqued by opportunities offered by a good teacher through a quality program to practice scientific methods with technology in order to meet the needs of the student and the local community.

The instructors moderately agreed that they were interested in infusing bioscience skills and knowledge into the study of agriculture. This information indicates the instructors' awareness of current developments taking place in the biosciences and their desire to exploit the opportunities. Hence, it can be concluded that they were interested in relating bioscience skills and knowledge into the study of agriculture.

The need for additional instructional materials for teaching the biosciences was recognized when the respondents ranked this item as the first among all perception statements. It could be speculated that whether the instructors were ready to infuse the biosciences into the study of agriculture at once or not, they felt the need for instructional materials pertaining to the biosciences. This premise is also supported by some other studies. Martin (1987) suggested that a model curriculum plan or guide should be developed for the new agriculture and its emphasis on the biosciences stressing the seven occupational areas of the agricultural industry and its global impact. A state-wide survey conducted by Vold (1988) in order to study the perceptions of vocational agriculture instructors towards the biosciences in Iowa, also found that additional instructional materials were required for infusing the biosciences into the study of agriculture. It was interesting to note that this statement also ranked first among all the nineteen perception statements included in the above mentioned study. This finding leads to the conclusion that vocational agriculture instructors did not possess sufficient instructional materials related to the biosciences and hence, it is assumed that they are greatly in need of those materials.

The following finding created an ambiguity as to whether the instructors would proceed to infuse the biosciences even though sufficient instructional materials would be made available to them. The agriculture instructors strongly agreed with the statement that it would take additional time to incorporate the biosciences into the study of agriculture. A Texas teacher supported this statement saying, "I don't feel we have enough kids to justify spending a lot of time in this new area." One might expect this reaction due to the nature of the diversified job responsibilities of vocational agriculture instructors ranging from classroom instruction to SOE programs. It can be concluded that the time factor might restrict the instructors to proceed with the bioscience infusion inspite of sufficient instructional materials and motivation by educators.

It was observed that the vocational agriculture instructors "some what" disagreed with the statement, "study of the biosciences would help in developing SOE programs." This finding could be attributed to the fact that vocational agriculture instructors may be unaware of science oriented SOE programs. However, there are some examples of science related SOE programs. According to Perry (1989), when students took ownership of agricultural projects such as maintenance of green houses, bedding plants, growing fruits and vegetables to sell at local markets for profit, they came to enjoy science more because they saw reasons to know about it. Also she stated that more intangible net profit for the students was a surge of enthusiasm for learning more about sciences related to these occupations. The Committee on Agricultural Education in Secondary Schools (1988) also supported this view by stating that a valuable SOE for a student could mean working as an elementary school teacher's aide and helping with a lesson plan in plant genetics. It can be concluded that the agriculture instructors were not very aware of SOE programs related to the biosciences.

The agriculture instructors perceived that the infusion of the biosciences would not strengthen FFA activities. In other words, they disagreed, to some extent, with the statement "infusion of the biosciences into vocational agriculture would strengthen FFA activities." It could be assumed that the way FFA functions might be a contributing factor for this finding. The committee report on Agricultural Education in Secondary Schools (1988) supported the assumption of the investigator when it found that vocational agriculture instructors are unduly driven by a desire to help students excel in traditional production oriented FFA contests and award programs. The National Organization of the FFA recognizes vocational agriculture teachers who have shown that they use agricultural science effectively in their instruction and also students who have demonstrated the agriscience principles in their research projects. Some other studies have supported the aforementioned view. The involvement of agriscience into the FFA was also encouraged by state action plans of the National Conference on Agriscience and Emerging Occupations and Technologies held in Orlando, Florida in 1988. One of these action plans was to develop an agriscience center at FFA summer camps (Williams and Pope, 1988). Moreover, the youngsters could conduct a series of outreach symposiums that explain the institute's curriculum and provide expert discussion on agriscience topics (Duval, 1988). It can be concluded that agriculture instructors might ignore the view that the biosciences strengthen the FFA activities due to the nature of how FFA currently functions.

Hill et al. (1986) found out that biological nitrogen fixation reduces the use of nitrogenous fertilizer which in turn leads to the conservation of fossil fuels used to produce ammonia which is the main source of raw material for the manufacture of nitrogen. The agriculture instructors agreed to some extent that the application of biotechnology such as biological nitrogen fixation would reduce dependency on environmentally undesirable chemicals. At the same time, they strongly disagreed with the statement, "biotechnology will promote chemical dependency." It could be speculated from the above findings that the respondents were aware of the negative impact of chemicals on the environment to a certain extent. The following reaction of one of the agriculture instructors could also be taken as a support for this finding: "biotechnology, in my opinion, would be helpful in feeding and clothing our world with a reduction in chemical dependence." It can be concluded that the instructors were aware of the information that application of biotechnology could reduce chemical dependency.

The agriculture instructors also agreed to the view that biotechnology will be useful for improving disease and insect resistant plant varieties and that biotechnology helps breeders to improve nutrient value of food and feed grains. This finding suggests that the instructors have knowledge about the recent developments in the technology of insect and disease resistant plant varieties using biotechnology.

Importance of Bioscience Competencies

The first objective of this study was to determine the level of importance of bioscience competencies in the study of agriculture. It was found out that most of the competencies related to the plant sciences were of high importance. Plant sciences that are related to production agriculture were also given high importance. Competencies that dealt with plant classification and certain new technologies such as hydroponics received moderate to low importance. This finding indicates that most of the competencies related to plant sciences were important to agriculture instructors.

Among the competencies in the area of genetics, the agriculture instructors gave higher importance to competencies related to plant breeding where as the competencies related to cell biology were rated low in importance. This contradicts the view of Malpiedi (1989) who stated that agriculture instructors are meticulous in their efforts to cross basic science concepts and principles with agricultural competencies. The competencies related to the category biotechnology were rated moderate in importance. It could be stated that many agriculture instructors are not aware of the fact that most traditional breeding methods are outdated. This is in accordance with the general trend in the agricultural profession (Doyle, 1987). One might expect that this finding was due to the fact that the competencies at the cellular level are being taught by the core science instructors in secondary schools. This information suggests that the competencies that deal with cell biology and biotechnology are not finding a place in the instruction of teachers of agriculture.

Among the animal science competencies, the competencies related to livestock production were given high importance in vocational agriculture programs. This finding is supported by Thomas and Groves (1986) who stated that teaching livestock production to agriculture students has traditionally been a major part of the secondary vocational agriculture program. The competencies related to the categories "animal systems" and "technology for growth" were given lower importance. This information is in line with the argument by Thomas and Groves (1986) which was that instructors tend to teach those manipulative skills which they are confident they themselves can perform effectively.

In the microbiology competency area, it was observed that none of the items were given a high importance rating. The competencies related to the category "structure and function of various microorganisms in agriculture" received the lowest rating. This information suggests that a lack of adequate laboratory facilities, unavailability of a compound microscope and lack of instructional materials might be the reasons for low instruction in this competency area. The area of food science has also received a moderate importance rating. It appeared that the production nature of vocational agriculture programs and the instructor's being unaware of the vast career scope in the field of food preparation and processing might have contributed to the lack of attention in this area. It can be concluded that most of the competency areas related to microbiology and food science were not being taught to a great extent in vocational agriculture programs.

Expansion of Instruction in the Biosciences

The second objective addressed by this study was to determine the degree to which vocational agriculture instructors would increase instruction in the biosciences given selected resources and inservice education.

Among the plant science competencies, the knowledge and skill areas that deal with principles of plant physiology and plant growth and development were rated highly. Moore (1987) supported such a need by providing an example: Observation of the pollinators in gathering pollen from female and male flowers of many fruit trees would require knowledge in pollination and fertilization. The competencies related to the category "plant classification" were rated low. While interpreting the findings, it seemed that the instructors due to lack of time, were not interested in analyzing how plant classification systems can provide insight into fundamental relationships between individuals in the plant kingdom. These findings suggested that the instructors had a low desire to teach competencies related to plant classification.

The instructors seemed interested in increasing instruction in the area of genetics and to some extent in biotechnology. At the same time, the instructors did not perceive expanding instruction in the category of "cell biology." This finding indicates that the instructors were unaware of the fact that the understanding of cell biology is essential for learning biotechnology. For instance, teaching gene splicing without understanding the structure and function of DNA would not only be a wrong approach but also serve no useful purpose. This view could also be related to the statement by Martin (1988b) that current developments in biotechnology cannot be understood by the students of vocational agriculture unless the fundamental principles of biology are taught. McCormick and Cox (1988) also supported this view that teaching specific facts of agribusiness and technology without blending the know-how aspects of the biosciences would not be educationally sound. A case example from the field illustrated that pupils after learning the structure and function of DNA in a cell, clone plants from single cells and experimenting with the propagation of pineapples and gooseberry plants in the laboratory in secondary schools (Perry, 1989). It can be concluded that though instructors have showed some interest in teaching biotechnology, they may be ignorant of how principles of cell biology are essential towards this new effort.

Among the animal science competencies, competencies related to the category "technology for growth" was given high priority for expansion of instruction. The researcher felt that agriculture instructors should have heard about cost feasible and economic gain technologies such as application of bovine growth hormone and porcine somatotropin. According to Norcross (1989), the recent advances in the application of porcine somatotropin decreases the amount of feed that animals consume to gain the same amount of body weight. The investigator suspected that a high ranking for the category "technology for growth" might be due to the fact that the instructors' awareness of the role of porcine somatotropin in increasing the body weight of swine for the same amount of feed consumed. At the same time, the low score for the category "animal systems" led the investigator to a conclusion that the instructors are less knowledgeable regarding how somatotropin causes the liver to stimulate the proliferation of cells in skin and cartilage which affects adipose tissue resulting in increasing protein deposition in the muscles of swine. This illustration directly reflects the theoretical framework provided by Martin (1988a) which stated that the students cannot understand biotechnology unless the underlying principles of biology are taught. Further, Braund (1986) also supported the argument by stating that it could be especially useful in recruiting in high school to tell the exciting story of biological research in animal science to students with career interest in biological sciences. It can be concluded that the instructors, though interested in infusing application aspects of biotechnology in animal science, are not positive towards teaching animal systems.

The high mean scores for expansion of competencies related to methods of maintaining water quality is not very surprising as this topic is becoming more and more of a priority at the national level in general and the midwest in particular. The passage of the Groundwater Protection Act of 1989 increased the visibility of the water quality issue (Weber, 1989). It could be speculated that higher mean scores in soil erosion control might be due to the increased awareness among instructors regarding conservation programs. More over, the conservation provisions of the Food Security Act of 1985 has generated instructional materials and visibility for the need for soil erosion control. It can be concluded that the involvement of considerable number of agriculture instructors in soil judging contests might have also contributed to high mean scores for expansion of instruction in the soil science area (Weber, 1989).

It was observed that the agriculture instructors gave low importance to expanding instruction relating to the category "structure and function of microorganisms" though they perceived that there should be instruction related to the category "role of microorganisms in agriculture." It appeared that the instructors possess a low understanding of the nature of microorganisms such as yeast, fungi, and bacteria. Mayer and McInerney (1984) supported the above assumption saying, "it is very difficult to develop an understanding about how microorganisms are cultured in large scale for specific uses unless the students clearly understand the nature of occurrence, structure, and reproductive capabilities of these beneficial organisms."

The food science competencies related to food processing, fermentation and new food products received the attention of the agriculture instructors by indicating a need for expansion of instruction in those areas. An assessment of the need for school community food preservation projects was conducted as early as 1982 in Louisiana also supports this finding (Kotrlick and Garland, 1982).

The study concluded that teachers, supervisors, and students agreed that food processing should be included in every high school vocational agriculture program. A Louisiana state instructor argued that food science would perhaps expand the view the public had about agriculture because everyone has to eat. The competencies related to microbial processes that take place in the preparation of food received the lowest rating by the instructors. This information indicated that the agriculture instructors were not fully aware of the fact that micro-organisms are directly involved in the successful outcome of numerous food production processes such as brewing, baking, sausage manufacture, fermentation of vegetable materials, sauerkraut pickles, and manufacture of fermented dairy products.

The fourth and final objective addressed by this study was to compare various groups of respondents regarding their perceptions on selected competencies and demographic factors. Significant differences among the NVATA Regions I, II, V, and VI were observed regarding expansion of instruction in the areas of plant science, genetics, microbiology, and food science. In other words, the mean scores in the regions I and II for expansion of instruction in the above competency areas were significantly less than regions V and VI. The investigator speculated that the instructors in regions I and II were more concerned about the point that the vocational agriculture program may weaken the objectives of vocational education if the instructors would get so heavily involved with the study of the biosciences. In the soil science competency area, the mean scores for soil science competencies in regions II and III are significantly higher than regions IV and VI. The investigator assumed that the instructors were well aware of soil and ground water problems in the regions II and III (midwest) than other regions and this fact contributed to their significantly high score. No significant difference in the animal science area was observed. This finding might be due to the fact that instructors in all the six regions placed more or less high emphasis on livestock production areas and low importance to competencies related to the study of animal systems.

Open Comments of the Respondents

Though only a few people reacted to the open comments section of the survey, certain useful conclusions were drawn. The vocational agriculture instructors in Region I were not very positive towards the survey. One of their major concerns was that the vocational agricultural program may weaken the objectives of vocational education if the instructors get so heavily involved with the biosciences. Most of the comments from the agriculture instructors of Region II were favorable to the infusion of the biosciences into the study of agriculture. However, one instructor felt that if too much of the bioscience were incorporated into high school programs, students aren't going to get experience in all areas of agriculture. It can be assumed that the instructors of this region understood to some extent that this new effort would develop learning opportunities for students in the areas other than production agriculture.

Though some instructors argued that they cannot handle the biosciences without relevant materials, Region III instructors strongly felt that certain changes in agricultural education are a must. One instructor in Region IV raised certain questions which might be interesting for all agricultural educators: "How practically is it to add the biosciences into the present curriculum without major redirection in my studies, requiring additional time at the university level?", "Are we not forgetting students that are not going on towards higher education?" The investigator left these questions to further research in this area.

The instructors in Region V had a desire to expand instruction in the biosciences. This effort had these limitations: need for instructional materials suited to the needs of their students and local community, conflicts with science department, and lack of hands-on experiences in the biosciences. The instructors in Region VI were very much interested in infusing the biosciences though they expressed their concern regarding additional costs. The investigator speculated that the instructors throughout the country were willing to move toward this direction inspite of a considerable amount of apprehension. It can also be assumed that the limitations posed by instructors vary from region to region. But the need for instructional materials and inservice education did not seem to vary much throughout the length and breadth of the nation.

Implications

The discussion of findings led to the following implications:

1. Overall, the instructors had developed a certain awareness for the infusion of the fundamental principles of the biosciences into the study of agriculture.
2. The instructors' neutral view of the role of the bioscience in diversifying career opportunities for students, the biosciences related SOE programs and strengthening FFA activities implied their unrealistic view of agricultural job

prospects and their being unaware of current developments in agricultural biotechnology.

3. The results of this study indicate that the instructors had doubts regarding student involvement in a program of vocational agriculture which focus on the biosciences.
4. It was clear that additional instructional materials were needed and this need was felt throughout the country inspite of certain limitations.
5. Further, the instructors indicated an interest in infusing the biosciences into the curriculum and wanted to take advantage of the opportunities.
6. The instructors' perceptions of the bioscience competencies were to some extent contradictory to their perceptions regarding teaching the biosciences in agriculture.
7. The information regarding the importance of the biosciences and the need for more materials indicated an interest in infusing the biosciences into the curriculum.
8. Instructors perceived that they would expand instruction in related areas: plant growth and development, technology regarding animal growth, soil problems and ground water quality, food products and processing. This finding imply that the instructors were aware of these areas and might be used to reshape the image of vocational agriculture programs.
9. At the same time, some instructors' perceptions regarding instructional expansion in areas like animal systems, cell biology, nature and properties of soil, structure and function of microorganisms and microbial process in food implied their lack of desire to learn innovative approaches to teaching, lack of laboratory facilities, narrow vision of the

fundamental principles of the biosciences and their impact on agriculture and their lack of motivation.

CHAPTER VI. SUMMARY AND RECOMMENDATIONS

Introduction

Bioscience is defined as "any science whose systematized knowledge and principles are applied to the functions and problems of living organisms" where as biotechnology refers to "any technique that uses living organisms to make or modify products, to improve plants and animals, or to develop microorganisms for specific use". Biotechnology with all its inherent complexities, mysteries, problems and challenges, promises to revolutionize farming and agriculture. With speed and accuracy, biotechnology promises to remedy all manner of agricultural problems confronting every society attempting to feed itself (Doyle, 1985). In animal production, for instance, it holds the potential of magnifying productivity, accelerating cross-breeding program, even altering the genetic makeup of animals (Fowler, 1987).

And while cloning of an embryo is already a reality, researchers dream of applying genetic engineering to accomplish such goals as a corn plant which could fix its own nitrogen supply, or present day annual crops which could be bred to rejuvenate by themselves. Biotechnology is being applied to food processing and manufacturing, to new methods for ecologically sound disposal of wastes, and to biochemical engineering of crop residues (Clarke, 1986). According to a recent survey of knowledgeable representatives of the farming, industrial, government, and academic sectors projected biotechnology to provide 40 percent of the innovations for crop production in the year 2005 while traditional technologies was expected to provide only 30 percent (Hardy, 1985).

Statement of the Problem

The possibilities are limited only by imagination and initiative among researchers. 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. Because of the emergence of these industries, the need for developing an awareness of the scientific foundation of the agricultural industry is becoming one of the major issues of our time. As new careers are springing up, and diverse opportunities examined, a challenge to prepare for these opportunities is facing the educational field, particularly vocational educators. Moreover, the current developments in the field of biotechnology cannot be understood by the students of vocational agriculture unless the fundamental principles of the biosciences are taught (Martin, 1988a).

The National Study on Agricultural Education in Secondary Schools (1988) also emphasized the need for a change and stated that the current vocational agriculture programs and the FFA are not meeting the broader needs for agricultural education generated by changes in the food and fiber industries and society as a whole. In addition, revitalization of high school agriculture programs is necessary for solving problems such as declining enrollments and lack of student interest (Luft and Peterson, 1989). This new effort would also meet the needs of students when they discover a purpose in being a school and they feel important and valuable while dealing with their own enterprises. The technological developments cannot be applied in the field of agriculture, if vocational agriculture teachers lack knowledge about how to use the biosciences in the study of agriculture. Realizing the need for the infusion of the biosciences into vocational agriculture, the Iowa Technical Committee on Biotechnology (1987) recommended that educators should infuse more of the biosciences into the vocational agriculture curriculum in order to prepare students for the highly sophisticated agricultural industry of the future.

This information formed the basis for some key questions:

1. What bioscience skills and knowledge and skills be taught in vocational agriculture programs?
2. To what degree are teachers willing to infuse more science into their courses?
3. What incentives do teachers need to infuse more science into the curriculum?

Purposes and Objectives

This study attempted to identify the perceptions held by teachers of agriculture in the U.S.A. regarding the infusion of the biosciences into the study of agriculture. It also sought to measure the degree of acceptance which could be expected on the part of teachers as further efforts were implemented to infuse the biosciences into vocational agriculture programs across the nation. Additionally, the purpose of the study was to lay some groundwork for future research and development of instructional materials in the area of the biosciences. Since biotechnology has stirred a great deal of interest throughout all levels of education, it was considered appropriate to begin any new reform and/or advancement by first describing what already existed and then establishing priorities for potential curriculum changes.

The specific objectives of the study were:

1. To identify the level of importance of the biosciences in vocational agriculture as perceived by agriculture instructors,

2. To identify the degree to which vocational agriculture instructors would increase instruction in the biosciences given selected resources and inservice education,
3. To determine the perceptions held by vocational agriculture instructors regarding teaching the biosciences, and
4. To compare the various groups of respondents regarding their perceptions on selected bioscience competencies and demographic factors.

Procedures

This study began with a review of literature and development of a questionnaire. A list of 125 bioscience knowledge and skill areas was compiled utilizing the curriculum guide developed by the Iowa Technical Committee on Biotechnology (1987) which consisted of fifteen members representing various industries and areas of interest including agronomy, animal science, horticulture, veterinary medicine, vocational education, and the biotechnology industry. Six bioscience-based areas were used in order to facilitate data collection:
1. Plant science, 2. Genetics, 3. Animal science, 4. Soil science, 5. Microbiology, and 6. Food science. The compilation of the knowledge and skill statements was done utilizing the following criteria:

1. Knowledge and skills directly contribute to the applied sciences.
2. Knowledge and skills have a direct impact on student career opportunities.
3. Knowledge and skills have a relationship to the seven occupational areas of the agricultural industry.
4. Knowledge and skills reviewed and approved by a panel of experts.

The survey instrument utilized a Likert-type scale with points ranging from 1 to 5 as the method for obtaining the data. The scale was used to collect information regarding teacher attitudes and perceptions in the following areas:

1. Extent to which this knowledge or skill area was important.
2. Extent to which the teacher would expand instruction in this knowledge or skill area given needed materials and inservice education.

Once the survey instrument was completed, it was pilot-tested by fifteen agriculture teachers in order to establish content validity.

The study was national in scope. Vocational agriculture instructors from all fifty states were included in the population. The target population for the study was 10, 102 vocational agriculture instructors in the U.S.A. An adequate sample size for this study was determined to be five percent of the population (Seshan, 1979). A proportionate stratified random sampling method was adopted in order to select the sample. To ensure that the sample was representative of all groups, the population was stratified into six groups based on the six regions of the National Vocational Agriculture Teachers Association (NVATA). The sample size drawn was 505.

The questionnaires were mailed to all vocational agricultural instructors. Two follow-ups letters were sent. This process generated 237 responses with a response rate of forty-seven percent. A follow-up of non-respondents yielded no significant practical or statistical differences between the responses of those participating in the survey and those choosing not to participate.

Analysis of Data

In analysis of the data, the mean scores and standard deviations were computed for all the listed bioscience competencies to determine the level of importance as perceived by agriculture instructors and also to determine the degree to which these instructors would expand instruction in the selected bioscience competencies. A one-factor analysis of variance was computed in order to compare the six regions regarding the bioscience competencies that were perceived to be important and regarding the degree to which they would expand instruction in these competencies. A correlational analysis was conducted using Pearson product moment procedure. The Tukey method was used as a post-hoc analysis to identify where the differences among the regions existed.

Results / Findings

In analysis of the data, the researcher found various tendencies and trends which seemed to indicate a pattern of agreement or disagreement. Item analysis provided information regarding the infusion of specific student skills. Major categories or groups of data were identified and prioritized. The first major trend which established itself was that of overall agreement among all teachers surveyed that infusing bioscience competencies into vocational agriculture is moderately to highly important.

More specifically, soil science was defined by all teachers to be highly important. Animal science competencies were considered to be important. Plant science and genetics competencies were considered to be moderately important. Microbiology and food science knowledge and skills lagged behind, being termed of low importance. When asked for the degree of expansion which they would attempt in infusing the biosciences into the study of agriculture, instructors seemed in agreement that animal science and genetics knowledge and skills should be expanded significantly and this was followed by plant science. Microbiology received the lowest ranking for expansion of competencies.

The respondents varied in their responses by region. The respondents in NVATA region five consistently perceived that the bioscience competencies should be taught to a greater extent that the respondents in regions one and two.

Overall, the respondents strongly agreed with the statement that additional instructional materials were required for infusing the biosciences into the curriculum. The teachers perceived that "learning the biosciences would help students to better understand agriculture." Age of instructors was positively related to the degree to which the biosciences should be infused into the curriculum. A correlation analysis between certain demographic factors and perception statements revealed both positive and negative results. It was found that as the instructors' age increased, their agreement also increased concerning the statement: "learning biosciences would help students to better understand agriculture." It was interesting to find that the perception statement "additional instructional materials are required for infusing the biosciences into the study of agriculture" was negatively correlated with the educational qualifications of the teachers.

Implications

The instructors in general had developed a certain awareness concerning the infusion of biosciences. Further, the instructors' interest towards infusion of biosciences implies their desire in utilizing the opportunities. Instructors' "neutral" view on the factors such as role of bioscience in diversifying career opportunities for students and bioscience related supervised occupational experience programs, implies their unrealistic view of agricultural job prospects. It is clear that additional instructional materials are needed and the need is felt throughout the country. The instructors' perceptions were found to be contradictory in a few cases. For instance, though they agreed with the statement "learning fundamental principles of biology would help would help students understand agriculture", the instructors didn't indicate that instruction should be expanded in competencies related to fundamentals such as cell biology etc.

The instructors perceived a need to expand instruction in areas such as plant growth and development, technology for animal growth, soil problems and ground water quality, food products and processing. This perception could be attributed to the teachers' awareness of the growing areas of agricultural science and teachers enthusiasm may result in shaping a better image of vocational agriculture programs. On the other hand, when the instructors' ranked the following areas low: animal systems, cell biology, structure and function of microorganisms, and microbial process in food, it indicated their fear of the subject content, and the lack of laboratory facilities and materials.

Conclusions

The main conclusion from this study was that changes resulting from biotechnology in agriculture are here to stay. This thought was reflected in the instructors' comments. Most of the negative responses of the instructors were due to their fear of change, need for new subject content, lack of instructional materials, doubts regarding how far this new effort would help to meet their students' needs, lack of funds, conflict with science departments, lack of encouragement from administrators, etc. Even in the midst of these concerns biotechnology was seen as the wave of the future. Infusing bioscience instruction into secondary agriculture programs is the first step towards riding that wave. It is clear that agriculture programs must face this new reform or advancement in the years to come will be halted.

Recommendations

The following recommendations were made based on the findings of this study and the review of literature:

1. A link should be established among biotechnology industries, agricultural educators, and teachers. This linkage would help develop job related skills for students of vocational agriculture. This effort would also result in getting funds for high school laboratory and equipment related to biotechnology.
2. Instructional materials development should be focused on principles of biosciences and applications of biotechnology.
3. Agricultural educators should be involved in designing a model instructional program focused on the biosciences in agriculture.
4. Inservice training programs should be conducted for teachers to expand their agriscience knowledge and use of innovative approaches to teaching.
5. School policies should be set which allows science credit to be granted to high quality agriculture courses.
6. Teachers should explore science-related supervised occupational experience programs and FFA programs involving biotechnology industries thereby improving the image of the vocational agriculture program in the years to come.

Recommendations for Further Study

1. Studies should be conducted which focus on the level of student learning of the bioscience knowledge and skills by using different teaching methods.

2. A study should be conducted to identify specific science related supervised occupational experience programs suited to the local school environment.
3. A study should be conducted to evaluate the perceived impact of biotechnology on agriculture in general and farming in particular.
4. Research should be conducted to identify the ethical issues involved in biotechnology research and practice.

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APPENDIX A. REGION-WISE MEANS, AND STANDARD DEVIATIONS FOR THE LEVEL OF IMPORTANCE OF BIOSCIENCE COMPETENCIES AS PERCEIVED BY TEACHERS OFAGRICULTURE

Table A-1. Means and standard deviations for the level of importance of competencies in plant science as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
List the ways plants are classified	M	3.89	3.63	3.67	3.82	4.38	3.92
	SD	0.91	0.76	0.80	0.85	0.54	0.87
Draw the internal structure of leaves	M	3.28	3.11	3.35	3.40	3.83	3.29
	SD	0.85	1.03	0.98	0.88	1.00	0.95
Conduct experiment for photosynthesis and respiration	M	3.92	3.40	4.11	3.82	4.02	3.74
	SD	0.90	0.90	0.59	0.89	1.08	1.05
Explain the function of roots	M	4.64	4.19	4.05	4.31	4.58	4.45
	SD	0.62	0.85	0.66	0.71	0.64	0.57
Describe the internal structure of a stem	M	4.00	3.55	3.76	3.71	4.27	3.88
	SD	1.01	0.84	0.85	0.82	0.65	0.84
Identify various modifications of a stem	M	3.46	3.22	3.55	3.68	3.91	3.81
	SD	0.88	0.98	1.07	1.18	0.87	0.87
Describe the structure of a flower	M	4.32	3.33	3.67	4.02	3.86	3.92
	SD	0.81	1.04	1.17	1.01	0.89	0.99
Describe the functions of each floral part	M	4.28	3.23	3.82	3.68	3.75	3.81
	SD	0.89	1.01	1.24	1.23	0.73	1.00
Describe the process of pollination and fertilization	M	4.53	3.97	4.11	4.31	4.16	4.48
	SD	0.57	0.87	1.20	0.90	0.84	0.89
Identify the vegetative propagation in plants	M	4.42	3.72	3.67	4.02	4.08	4.44
	SD	0.57	1.00	1.17	0.85	0.87	0.80
Demonstrate budding and grafting	M	4.03	3.75	3.97	3.94	4.13	4.14
	SD	0.92	1.02	1.11	1.08	0.76	1.02

Table A-1 Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the formation of fruits	M	3.53	3.22	3.44	3.68	4.41	4.14
	SD	0.79	1.04	1.05	1.05	0.88	1.14
Describe the formation of seeds	M	3.96	3.47	3.61	3.94	4.11	4.03
	SD	0.88	1.08	1.28	1.11	0.95	0.80
Conduct a germination experiment to show the stages of germination of seeds	M	4.32	3.88	3.85	4.00	4.22	4.18
	SD	0.77	1.00	1.39	1.13	0.95	0.96
Dissect a plant and name the parts	M	3.35	3.44	3.94	3.71	3.77	3.70
	SD	1.19	1.10	1.15	1.27	1.07	1.03
Identify important weeds of crop plants	M	4.07	3.86	3.94	4.42	4.30	4.33
	SD	0.97	0.87	1.25	0.88	0.85	0.78
Demonstrate the foliar application of nutrients in plants	M	3.57	3.30	3.88	4.08	4.30	4.29
	SD	0.87	0.92	1.17	0.95	0.85	0.85
Demonstrate the practice of hydroponics	M	3.14	3.44	3.70	4.00	4.22	4.22
	SD	1.20	1.10	1.11	1.05	0.89	1.15
Explain the stock selection in plants	M	3.21	3.08	3.50	3.82	4.13	3.88
	SD	1.06	0.96	1.13	0.89	0.86	0.97
Explain the importance of apical meristem in growth	M	3.32	2.88	3.52	3.57	3.86	3.59
	SD	1.15	1.11	1.33	0.97	1.09	0.93
Demonstrate the process of uptake of water and nutrients by plants	M	4.21	3.61	4.00	4.14	4.13	4.03
	SD	0.97	0.87	1.32	0.81	0.99	1.12
Describe how nitrogen fixation takes place in leguminous crops	M	3.82	3.80	3.61	4.28	4.25	4.03
	SD	0.90	0.92	1.19	0.82	0.87	0.83
Demonstrate the effect of growth hormone on the rate of sprouting	M	3.50	3.44	3.67	4.02	4.25	3.81
	SD	0.96	0.90	1.19	0.82	0.87	0.83

Table A-1 Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Record through observation the development of a plant	M	3.50	3.36	3.76	3.91	4.25	4.88
	SD	1.07	1.04	1.25	0.91	0.93	1.15
Explain the short night and long night plants	M	3.32	2.94	3.55	3.88	4.08	4.03
	SD	1.15	1.04	1.26	0.90	0.96	1.09
Identify some growth regulators	M	3.71	3.22	3.79	3.68	4.16	4.07
	SD	0.89	0.92	1.22	1.05	0.91	1.17
List the limiting factors of plant growth	M	4.32	3.55	4.02	4.02	4.30	4.22
	SD	0.81	1.05	1.26	1.01	0.88	0.97
Demonstrate the selective action of herbicides	M	4.10	3.80	4.14	4.31	4.36	4.32
	SD	0.83	1.09	1.01	0.79	0.85	0.87

Table A-2. Means and standard deviations for the level of importance of competencies in genetics as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Distinguish between a plant cell and an animal cell	M	3.77	3.52	3.80	3.82	4.36	3.85
	SD	0.93	0.91	0.83	1.04	0.89	0.92
Take a cross-section of a plant part and observe the cell through the microscope	M	3.74	3.38	3.68	3.91	4.11	4.03
	SD	0.90	0.93	0.83	1.06	0.82	0.89
Draw a plant cell and an animal cell	M	3.55	3.52	3.40	3.60	4.16	3.53
	SD	1.01	1.05	0.84	1.00	0.91	0.96
Describe the function of DNA	M	3.66	3.44	3.54	3.94	4.33	3.70
	SD	1.03	1.05	0.70	0.87	0.75	1.13
Explain the process of gene splicing	M	3.48	3.30	3.68	3.77	4.13	3.70
	SD	1.25	1.14	0.75	1.00	0.99	1.10
Describe the process of tissue culture	M	3.77	3.19	3.94	3.91	4.08	4.00
	SD	1.21	1.14	1.05	1.09	1.07	1.10
List various plant breeding technique	M	4.11	3.83	3.71	4.17	4.11	4.14
	SD	1.08	0.99	1.22	0.95	0.78	0.86
Explain the advantages of crop improvement	M	3.81	3.61	3.68	4.25	4.19	4.00
	SD	1.17	1.05	1.07	0.85	0.82	0.92
Describe the cloning of genes	M	3.51	3.33	3.80	4.03	4.02	3.88
	SD	1.22	1.26	1.20	1.07	1.00	0.97
Describe how mutation takes place in plants	M	3.22	3.41	3.60	3.48	4.05	3.74
	SD	1.18	1.05	1.28	1.05	0.89	0.98
Explain the formation of recombinant DNA	M	3.18	2.97	3.58	3.60	3.97	3.44
	SD	1.27	1.29	1.20	1.21	1.05	1.05

Table A-2. Continued

Competencies		Respondent groups 1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
State Mendel's law of inheritance	M	3.14	3.27	3.40	3.82	3.91	3.63
	SD	1.35	1.08	1.19	1.27	0.87	1.30
Explain the process of gene insertion into germ cell lines	M	3.51	3.19	3.22	3.54	3.75	3.63
	SD	1.12	1.16	1.16	1.24	0.96	1.07
Describe the process of natural selection of plants	M	3.40	3.61	3.51	4.00	3.83	3.81
	SD	1.15	1.00	1.17	1.02	0.69	1.07
Enumerate the difference between traditional plant breeding and gene splicing	M	3.48	3.22	3.82	3.82	4.05	3.81
	SD	1.18	1.24	0.98	1.01	0.98	0.92
Describe the advantages of gene splicing	M	3.59	3.19	3.74	3.71	4.00	3.80
	SD	1.15	1.32	1.03	1.10	1.09	1.01
Explain the role of monoclonal antibodies in pregnancy testing	M	3.07	2.88	2.82	4.34	3.77	3.40
	SD	1.23	1.32	1.03	1.10	1.09	1.01
Explain the process of transgenesis	M	3.25	2.86	3.02	3.28	3.66	3.51
	SD	1.25	1.31	1.15	1.26	0.95	1.15
Describe the role of gene splicing in the production of bovine and porcine somatotropin	M	3.07	3.13	3.45	3.68	3.80	3.44
	SD	1.26	1.29	1.14	1.25	1.09	1.18
Distinguish between in-breeding and out-breeding in animals	M	3.51	4.05	3.91	4.20	4.22	3.40
	SD	1.28	0.82	1.22	1.07	0.76	1.05
List the methods of breeding in swine	M	3.40	3.94	3.88	4.40	4.22	3.96
	SD	1.24	0.89	1.27	0.93	0.79	1.12
List the criteria for selecting breeding stock	M	3.51	4.36	3.99	4.40	4.41	4.18
	SD	1.19	0.85	1.31	0.94	0.60	1.07
Explain the process of embryo transfer	M	3.96	4.19	4.17	4.37	4.27	4.44
	SD	1.15	1.00	1.07	0.87	0.84	0.75

Tsble A-2 Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the principle of developing disease and insect resistant crops	M	3.77	4.11	4.25	4.25	4.13	4.11
	SD	1.03	0.97	1.01	0.88	0.89	1.01
Describe gene expression	M	3.70	3.63	3.54	3.97	4.05	3.81
	SD	1.43	1.52	1.47	1.03	0.98	1.29

Table A-3. Means and standard deviations for the level of importance of competencies in animal science as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Identify classification of livestock species	M	3.11	3.88	3.77	4.11	4.16	3.70
	SD	1.28	1.16	1.33	0.90	0.84	1.32
Draw the digestive system of ruminant and monogastric animals	M	3.29	3.66	3.88	4.20	4.02	3.70
	SD	1.23	1.12	1.30	0.99	1.00	1.26
Calculate the balanced feed ration	M	3.29	3.88	3.94	4.31	4.16	4.11
	SD	1.17	1.06	1.44	0.96	0.84	1.28
Explain the role of bovine growth hormone in milk production	M	3.40	3.63	4.00	3.97	3.94	3.88
	SD	1.15	0.99	1.26	0.95	0.98	1.01
Describe the composition of meat and milk	M	3.40	3.58	3.82	3.88	4.05	3.92
	SD	1.33	1.10	1.17	0.96	0.89	1.17
Describe the reproductive system of selected animals	M	3.40	3.83	3.91	4.02	4.00	3.66
	SD	1.15	1.05	1.29	1.04	0.98	1.20
Demonstrate the procedure of artificial insemination	M	3.74	4.02	4.00	4.22	4.28	4.14
	SD	1.02	1.02	1.16	0.84	0.99	1.06
List the factors for the selection of animal breeds	M	3.48	3.91	3.88	4.42	4.16	4.03
	SD	1.12	1.10	1.38	0.69	0.87	1.22
Describe the symptoms of major animal diseases	M	3.70	4.00	3.77	4.28	4.19	4.22
	SD	1.13	0.98	1.37	0.75	0.85	1.01
Outline the procedures to control animal diseases	M	3.85	4.05	3.85	4.34	4.25	4.18
	SD	1.16	1.04	1.19	0.72	0.80	1.07
Explain the principle of immunization in animals	M	3.59	4.00	3.82	4.28	4.16	4.14
	SD	1.16	1.04	1.20	0.78	0.81	1.09
Demonstrate the use of vaccines against major animal diseases	M	3.63	4.05	3.71	4.31	4.13	4.11
	SD	1.18	1.12	1.15	0.79	0.86	1.05

Table A-3. Continued

Competencies		Respondent groups 1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the principle of sex linkage in animal diseases	M	3.44	3.50	3.45	3.82	4.00	3.81
	SD	1.12	1.18	1.12	0.79	0.92	1.07
Analyze the ingredients of selected animal products	M	3.18	3.36	3.51	3.65	3.94	3.74
	SD	1.03	1.24	1.17	0.87	0.95	1.25
Explain how cycling time can be increased in animal production	M	3.33	3.61	3.57	3.85	4.11	3.88
	SD	1.03	1.15	1.09	0.91	0.88	1.18
Explain the function of endocrines in animals	M	3.44	3.38	3.42	3.62	4.08	3.77
	SD	1.03	1.15	1.09	0.91	0.88	1.18
Explain the physiology of lactation egg production in animals	M	3.29	3.88	3.94	4.31	4.16	4.11
	SD	1.17	1.06	1.45	0.96	0.84	1.28

Table A-4. Means and standard deviations for the level of importance of competencies in soil science as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the nature and properties of soil	M	4.25	4.02	4.51	4.51	4.47	4.70
	SD	0.94	0.87	0.77	0.61	0.87	0.54
Analyze an on-site soil profile to illustrate types of soil	M	4.07	3.72	4.28	4.48	4.69	4.48
	SD	1.03	0.81	0.75	0.61	0.62	0.64
List the macro and micro nutrients of soil	M	4.40	4.02	4.34	4.40	4.41	4.74
	SD	0.88	0.91	0.76	0.69	0.80	0.52
Distinguish between soil texture and structure	M	4.37	3.88	4.42	4.48	4.55	4.66
	SD	0.68	1.00	0.77	0.65	0.61	0.51
Explain soil alkalinity, salinity and acidity	M	3.70	3.52	4.20	4.60	4.66	4.59
	SD	1.35	1.15	0.71	0.60	0.77	0.57
Demonstrate the methods of soil conservation	M	3.63	3.61	4.37	4.60	4.83	4.66
	SD	1.33	1.02	0.73	0.55	0.44	0.55
Explain soil compaction	M	3.66	3.88	4.22	4.40	4.69	4.55
	SD	1.24	1.03	0.80	0.65	0.57	0.57
Demonstrate how to take soil samples and interpret soil test results	M	3.33	3.58	4.54	4.68	4.86	4.51
	SD	1.38	1.05	0.77	0.58	0.42	0.75
Demonstrate Cation Exchange Capacity of soil	M	3.59	3.77	3.65	3.91	4.27	4.11
	SD	1.18	0.95	0.76	0.85	0.77	0.93
Measure electrical conductivity and soil pH	M	3.22	3.44	3.82	3.84	4.13	3.70
	SD	1.12	1.05	0.77	0.86	0.93	1.17
List the environmental factors contributing to soil erosion	M	3.03	3.36	4.45	4.65	4.77	4.59
	SD	1.16	1.09	0.70	0.53	0.54	0.89

Table A-4. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain soil erosion control measures	M	3.66	3.80	4.45	4.57	4.83	4.51
	SD	1.35	1.00	0.74	0.55	0.44	0.93
Distinguish between conservation tillage and conventional tillage	M	3.88	3.97	4.31	4.48	4.66	4.59
	SD	1.36	1.02	0.75	0.70	0.79	0.74
Explain the biological properties of soil	M	3.55	3.77	4.22	4.22	4.69	4.33
	SD	1.12	1.01	0.77	0.70	0.71	0.87
Demonstrate the methods of maintaining water quality	M	3.70	3.58	4.37	4.37	4.83	4.33
	SD	1.29	0.99	0.69	0.73	0.51	1.00
Describe the principles of organic farming	M	4.00	3.91	3.62	4.00	4.38	4.00
	SD	1.14	1.05	0.80	0.92	0.83	0.91
Describe the importance of soil organic matter	M	3.11	3.25	4.20	4.48	4.63	4.51
	SD	1.15	1.02	0.90	0.65	0.54	0.80
Describe the cycle of soil ecosystem	M	3.51	3.77	4.02	3.80	4.33	4.03
	SD	1.15	1.07	0.70	0.83	0.95	0.94
Describe soil formation	M	3.59	3.33	4.17	4.11	4.38	4.07
	SD	1.11	0.94	0.85	0.83	0.87	0.82
Describe soil water availability	M	3.22	3.36	4.25	4.14	4.69	4.22
	SD	1.34	0.89	0.81	0.81	0.74	0.71
Demonstrate water holding capacity of soil	M	3.63	3.47	4.22	4.14	4.72	4.32
	SD	1.21	1.02	0.80	0.77	0.61	0.74
Develop pH scale to plot acidity and alkalinity	M	3.63	3.55	3.80	3.85	4.72	4.12
	SD	1.21	1.02	0.96	0.87	0.65	0.97
Identify pH ranges for major crops	M	3.22	3.30	4.05	4.32	4.86	4.60
	SD	1.18	0.92	0.96	0.73	0.54	0.64

Table A-5. Means and standard deviations for the level of importance of competencies in microbiology as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Demonstrate the operation of compound microscope	M	3.44	3.19	3.71	3.60	4.02	3.51
	SD	1.18	1.03	0.82	0.91	0.87	0.84
Describe the ways of classifying microorganisms related to agriculture	M	3.44	3.13	3.71	3.62	4.08	3.48
	SD	1.08	1.07	0.86	0.73	0.84	0.80
Distinguish between fungi and bacteria related to agriculture	M	3.59	3.36	3.88	3.68	4.08	3.63
	SD	0.97	1.04	0.79	0.86	0.87	0.79
Draw the structure of algae	M	2.74	2.77	3.02	3.20	3.80	3.07
	SD	1.13	0.98	0.82	0.86	1.03	1.00
Draw the structure of selected fungus in agriculture	M	2.85	2.75	3.08	3.12	3.75	3.07
	SD	1.19	1.02	0.98	0.94	0.99	1.10
Explain reproduction in fungi	M	2.92	2.83	3.11	3.22	3.86	3.37
	SD	1.14	1.10	0.83	0.97	0.99	0.96
Draw the structure of yeast	M	2.40	2.61	2.91	2.97	3.91	3.00
	SD	1.24	1.12	0.81	0.81	1.02	1.10
Observe the structure and composition of a bacteria under the microscope	M	3.00	2.91	3.40	3.34	4.00	3.40
	SD	1.27	1.13	1.11	0.99	1.01	1.01
Identify the difference between autotropic and heterotropic microbes	M	3.14	2.91	3.02	3.22	3.97	3.55
	SD	1.06	1.10	1.01	0.87	0.97	1.01
Identify the symptoms of major diseases of agronomic plants	M	3.74	3.58	3.97	3.94	4.38	4.41
	SD	0.90	1.02	0.98	0.80	0.80	0.89
List beneficial microbes in agriculture	M	3.70	3.58	3.91	3.81	4.19	3.85
	SD	0.86	1.07	1.09	0.83	0.85	1.02

Table A-5 Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Demonstrate culturing of micro-organisms in the laboratory	M	3.40	3.08	3.51	3.34	4.00	3.63
	SD	0.93	1.07	1.04	0.96	0.89	0.92
Identify nitrogen fixing organisms and explain how they fix nitrogen	M	3.74	3.69	3.91	4.00	4.33	4.14
	SD	0.90	1.11	0.95	0.92	0.75	0.94

Table A-6. Means and standard deviations for the level of importance of competencies in food science as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the importance of yeast to man	M SD	3.34 1.13	3.45 1.15	3.51 1.35	3.80 1.06	3.63 1.06	2.95 0.96
Explain the microbial process that takes place during the preparation of bread	M SD	2.88 1.08	2.85 1.21	3.28 1.31	2.37 1.23	3.75 1.08	3.48 1.01
List the fungi used in the manufacture of cheese	M SD	3.07 1.23	2.71 1.20	3.60 1.33	3.54 1.17	3.88 0.97	3.59 0.97
Identify the fungi that spoils fruits and vegetables	M SD	3.18 1.17	3.05 1.23	3.34 1.23	3.60 1.09	4.00 1.04	3.59 1.01
Explain the process of conversion of feed into meat in hogs and cattle	M SD	3.55 0.97	3.68 0.96	3.85 1.28	3.88 1.02	4.36 0.68	3.70 1.23
Describe the process of milk formation in cattle	M SD	3.59 0.88	3.51 0.99	3.82 1.31	3.94 0.96	4.41 0.64	3.66 1.17
Explain how microbial activity in milk helps in the formation of milk products	M SD	3.29 1.17	3.31 1.32	3.74 1.42	4.00 0.97	4.22 0.86	3.59 0.97
Describe pasteurization of milk	M SD	3.44 1.18	3.45 0.98	3.82 1.20	3.91 0.91	4.22 0.79	3.85 1.02
Identify various food preservatives	M SD	3.00 1.45	3.48 1.13	3.68 1.26	3.57 1.04	4.00 1.00	3.39 1.64
Describe the process of fermentation	M SD	3.37 1.04	3.28 0.95	3.51 1.31	3.82 0.95	4.02 0.84	3.70 0.95
Demonstrate the laboratory preparation of vinegar	M SD	3.44 1.01	3.25 1.03	3.57 1.24	3.74 0.97	4.02 0.91	3.55 0.93

Table A-6. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe how vinegar is used in the manufacture of canned beverages	M	2.66	2.74	3.14	3.02	3.75	3.40
	SD	1.30	1.19	1.39	1.36	1.18	1.04
Explain the concept of food chain	M	2.74	2.77	3.14	3.20	3.69	3.25
	SD	1.28	1.08	1.41	1.25	1.06	0.98
Identify wholesale and retail cuts of meat	M	3.30	3.74	3.85	3.88	4.36	3.40
	SD	1.33	0.95	1.26	0.96	0.72	0.97
Explain the processing of milk and dairy products	M	3.44	3.85	3.91	4.31	4.44	3.85
	SD	1.01	0.87	1.29	0.79	0.69	0.98
Describe various methods of processing fruits and vegetables	M	3.33	3.60	4.08	4.17	4.33	3.74
	SD	1.00	0.91	1.24	0.89	0.82	0.98
Explain the role of barley malt as a flavor supplement in baking	M	3.25	3.48	3.74	4.00	4.22	3.59
	SD	1.02	0.95	1.31	0.84	0.86	0.93
Explain how nutritive value of feed grains can be improved through biotechnology	M	2.85	2.74	3.45	3.31	3.83	3.22
	SD	1.16	1.14	1.31	1.13	1.13	0.89
Identify some artificial sweeteners hat can be manufactured in the industry using biotechnology	M	3.63	3.60	4.02	3.94	4.02	3.59
	SD	1.04	.1.19	1.09	1.03	0.91	1.04

APPENDIX B. REGION-WISE MEANS, AND STANDARD DEVIATIONS FOR THE DEGREE TO WHICH INSTRUCTION WOULD BE EXPANDED IN BIOSCIENCE COMPETENCIES AS PERCEIVED BY TEACHERS OFAGRICULTURE

Table B-1. Means and standard deviations for the degree to which instruction would be expanded in plant science competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
List the ways plants are classified	M	3.17	3.41	3.38	3.74	4.13	3.59
	SD	1.18	0.93	1.10	0.98	0.72	1.01
Draw the internal structure of leaves	M	2.75	2.88	3.17	3.45	3.47	3.29
	SD	1.07	1.26	1.14	1.17	0.91	1.06
Conduct experiment for photosynthesis and respiration	M	3.82	3.47	4.17	3.91	3.77	3.92
	SD	0.98	1.02	1.02	1.12	1.01	1.03
Explain the function of roots	M	3.71	3.82	3.91	4.28	4.30	4.07
	SD	1.27	0.97	1.02	0.92	0.82	1.07
Describe the internal structure of a stem	M	3.32	3.36	3.85	3.65	4.27	3.74
	SD	1.21	0.83	0.82	0.90	0.65	0.85
Identify various modifications of a stem	M	3.07	3.75	3.97	4.14	4.11	4.30
	SD	1.05	0.99	0.93	0.75	0.91	0.779
Describe the structure of a flower	M	3.42	3.55	3.97	3.80	4.22	3.88
	SD	1.45	0.93	0.75	0.99	0.79	0.97
Describe the function of each floral part	M	3.53	4.36	4.50	4.45	4.52	4.70
	SD	1.45	0.68	0.61	0.65	0.73	0.40
Describe the process of pollinationand fertilization	M	3.85	3.86	4.20	4.20	4.41	4.55
	SD	1.17	0.93	0.72	0.75	0.94	0.57
Identify the modes of vegetative propagation in plants	M	3.89	3.77	3.97	4.14	4.36	4.29
	SD	1.22	0.92	0.57	0.84	0.79	0.66
Demonstrate budding and grafting	M	3.46	3.66	3.91	3.71	4.47	4.08
	SD	1.34	0.79	0.79	0.82	0.68	1.05

Table B-1. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the formation of fruits	M	3.32	3.80	4.05	3.91	4.36	4.07
	SD	1.18	0.82	0.88	0.78	0.72	0.87
Describe the formation of seeds	M	3.39	4.13	4.29	4.31	4.61	4.48
	SD	1.19	0.72	0.83	0.67	0.72	0.64
Conduct a germination experiment to show the stages of germination of seeds	M	3.67	3.66	4.00	3.62	4.11	3.70
	SD	1.30	0.92	0.85	1.06	0.91	0.99
Dissect a plant and name the parts	M	2.85	4.19	4.41	4.60	4.86	4.59
	SD	1.50	0.99	0.98	0.80	0.62	0.77
Identify important weeds of crop plants	M	3.50	3.61	3.85	3.94	4.69	4.29
	SD	1.50	0.99	0.98	0.80	0.62	0.77
Demonstrate the foliar application of nutrients in plants	M	3.42	3.38	3.94	3.62	4.41	4.14
	SD	1.06	0.99	1.09	0.91	0.69	1.02
Demonstrate the practice of hydroponics	M	3.14	3.30	3.70	3.68	4.38	4.14
	SD	1.26	0.85	0.90	0.79	0.76	0.77
Explain the stock selection in plants	M	2.96	3.00	3.41	3.48	4.27	3.55
	SD	1.17	0.89	0.89	0.91	0.91	0.89
Explain the importance of apical meristem in growth	M	2.89	3.91	4.41	4.17	4.55	4.18
	SD	1.19	0.80	0.78	0.74	0.90	0.92
Demonstrate the process of uptake of water and nutrients by plants	M	3.67	4.02	4.23	4.14	4.52	4.22
	SD	1.30	0.87	0.92	0.94	0.65	0.80
Describe how nitrogen fixation takes place in leguminous crops	M	3.21	3.41	3.97	3.91	4.33	3.81
	SD	1.13	0.99	0.93	0.85	0.71	0.78
Demonstrate the effect of growth hormone on the rate of sprouting	M	3.39	3.75	3.79	3.91	4.30	3.81
	SD	1.06	0.87	1.03	0.78	0.62	1.03

Table B-1. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Record through observation the development of a plant	M	3.32	3.25	3.64	4.02	4.47	3.92
	SD	1.02	0.93	0.91	0.66	0.65	0.99
Explain the short night and long night plants	M	3.00	3.47	3.58	3.77	4.55	4.14
	SD	1.30	0.84	0.74	0.84	0.80	0.86
Identify some growth regulators	M	3.39	3.86	4.32	4.25	4.80	4.29
	SD	1.25	0.89	0.84	0.70	0.57	0.91
List the limiting factors of plant growth	M	3.64	4.08	4.14	4.34	4.61	4.40
	SD	1.33	0.90	0.85	0.59	0.68	0.69
Demonstrate the selective action of herbicides	M	3.53	4.00	4.34	4.42	4.44	3.98
	SD	1.17	0.91	0.64	0.71	0.72	1.01

Table B-2. Means and standard deviations for the degree to which instruction would be expanded in genetics competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Distinguish between a plant cell and an animal cell	M	3.55	3.52	3.77	3.88	3.88	3.81
	SD	1.08	1.97	1.06	1.13	1.03	1.07
Take a cross-section of a plant part and observe the cell through the microscope	M	3.55	3.22	3.54	3.94	3.94	3.85
	SD	1.15	1.09	1.09	1.13	0.92	1.07
Draw a plant cell and an animal cell	M	3.44	3.13	3.34	3.71	4.02	3.33
	SD	1.15	1.14	1.05	1.22	0.94	1.10
Describe the function of DNA	M	3.59	3.30	3.54	4.00	4.16	3.33
	SD	1.11	1.14	1.12	1.05	0.87	1.10
Explain the process of gene splicing	M	3.59	3.22	3.82	3.74	4.25	3.92
	SD	1.33	1.07	0.77	0.85	0.99	0.99
Describe the process of tissue culture	M	4.11	3.72	3.91	4.17	4.44	4.22
	SD	1.01	0.97	0.91	0.70	0.73	0.75
List various plant breeding techniques	M	4.18	3.83	3.91	4.37	4.38	4.18
	SD	0.96	0.94	0.70	0.69	0.87	0.78
Explain the advantages of crop improvement	M	3.55	3.25	3.65	3.80	4.25	4.14
	SD	1.21	0.99	0.72	0.79	0.93	0.86
Describe the cloning of genes	M	3.70	3.47	3.62	3.65	4.25	3.92
	SD	1.13	1.02	0.64	0.72	0.80	0.87
Describe how mutation takes place in plants	M	3.22	3.02	3.37	3.48	4.25	3.48
	SD	1.21	1.05	0.80	1.01	0.90	1.12

Table B-2. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the formation of recombinant DNA	M	3.48	3.50	3.85	4.08	4.44	3.77
	SD	1.18	1.08	0.81	0.88	0.77	1.12
State Mendel's law of inheritance	M	3.29	3.16	3.42	3.37	4.22	3.59
	SD	1.23	1.02	0.77	1.16	0.95	0.97
Explain the process of gene insertion into germ cell lines	M	3.96	3.61	3.82	4.11	4.36	4.37
	SD	0.85	0.96	0.78	0.79	0.72	0.79
Describe the process of natural selection of plants	M	3.51	3.11	3.77	3.80	4.08	3.81
	SD	1.12	1.09	0.73	0.75	0.90	0.92
Enumerate the difference between traditional breeding and gene splicing	M	3.51	3.05	3.62	3.77	4.00	4.03
	SD	1.05	1.19	0.77	0.87	1.01	0.89
Describe the advantages of gene splicing	M	3.07	2.91	2.85	3.11	3.91	3.48
	SD	1.23	1.05	0.94	1.23	0.99	1.05
Explain the role of monoclonal antibodies in pregnancy testing	M	3.11	2.83	3.05	3.28	4.00	3.44
	SD	1.28	1.10	0.93	1.07	1.04	1.15
Explain the process of transgenesis	M	2.88	3.08	3.54	3.68	3.88	3.57
	SD	1.25	1.20	1.06	1.05	1.14	1.05
Describe the role of gene splicing in the production of porcine somatotropin	M	4.11	4.27	4.05	4.25	4.66	4.29
	SD	0.80	0.74	0.90	0.74	0.58	0.72
Distinguish between in-breeding and out-breeding in animals	M	3.66	4.05	3.97	4.34	4.50	3.96
	SD	0.96	0.86	0.78	0.72	0.73	0.80
List the methods of breeding in swine	M	4.07	4.36	4.31	4.40	4.66	4.37
	SD	0.91	0.79	0.79	0.77	0.53	0.74
List the criteria for selecting breeding stock	M	4.18	4.25	4.31	4.25	4.38	4.47
	SD	0.73	0.87	0.75	0.81	0.72	0.74

Table B-2. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the principle of developing disease and insect resistant crops	M	3.88	3.80	3.60	3.94	4.19	3.88
	SD	1.01	0.88	0.94	0.69	0.88	0.89
Describe gene expression	M	3.80	3.73	3.64	4.25	4.05	3.91
	SD	1.04	1.03	1.24	0.50	0.95	1.02

Table B-3. Means and standard deviations for the degree to which instruction would be expanded in animal science competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Identify classification of livestock species	M	4.00	4.08	4.08	4.22	4.50	4.25
	SD	1.03	0.87	0.91	0.64	0.73	0.81
Draw the digestive system of ruminant and monogastric animals	M	4.14	4.00	4.00	4.37	4.33	3.96
	SD	0.90	0.98	1.00	0.80	0.92	1.01
Calculate the balanced feed ration	M	4.07	4.22	4.37	4.40	4.44	4.44
	SD	0.87	0.98	0.73	0.65	0.80	0.75
Explain the role of bovine growth hormone in milk production	M	3.55	3.80	4.11	3.97	4.22	3.81
	SD	1.05	0.92	0.86	0.74	0.89	0.96
Describe the composition of meat and milk	M	3.37	3.72	3.80	3.94	4.36	3.96
	SD	1.18	0.97	0.83	0.90	0.86	0.94
Describe the reproductive system of selected animals	M	3.92	4.11	4.05	4.14	4.27	3.81
	SD	0.87	0.78	0.93	0.94	0.88	1.01
Demonstrate the procedure of artificial insemination	M	3.77	4.19	3.94	4.22	4.47	4.25
	SD	1.10	0.92	0.76	0.69	0.87	0.76
List the factors for the selection of animal breeds	M	3.92	4.27	4.31	4.42	4.61	4.40
	SD	0.95	0.74	0.75	0.69	0.76	0.79
Describe the symptoms of major animal diseases	M	3.96	4.22	4.05	4.37	4.55	4.40
	SD	0.94	0.83	0.76	0.64	0.82	0.79
Outline the procedures to control animal diseases	M	4.22	4.30	4.11	4.45	4.69	4.37
	SD	0.93	0.85	0.75	0.61	0.66	0.79
Explain the principle of immunization in animals	M	4.00	4.08	4.02	4.28	4.61	4.33
	SD	0.92	1.02	0.70	0.71	0.72	0.78
Demonstrate the use of vaccines against major animal diseases	M	3.81	4.19	3.88	4.22	4.61	4.25
	SD	1.00	0.82	0.71	0.73	0.72	0.76

Table B-3. Continued

. Means and standard deviations for the degree to which instruction would be expanded in animal science competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the principle of sex linkage in animal diseases	M SD	3.70 0.91	3.47 0.94	3.62 0.59	3.85 0.69	4.41 0.84	3.81 0.83
Analyze the ingredients of selected animal products	M SD	3.29 1.06	3.38 0.99	3.60 0.69	3.68 0.79	4.41 0.87	3.81 0.91
Explain how cycling time can be increased in animal production	M SD	3.51 0.89	3.75 1.02	3.85 0.73	3.94 0.68	4.58 0.77	3.92 0.78
Explain the function of endocrines in animals	M SD	3.33 0.73	3.66 0.98	3.62 0.73	3.80 0.90	4.52 0.77	3.70 0.95
Explain the physiology of lactation, egg production in animals	M SD	4.07 0.87	4.22 0.78	4.37 0.73	4.40 0.65	4.44 0.80	4.44 0.75

Table B-4. Means and standard deviations for the degree to which instruction would be expanded in soil science competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the nature and properties of soil	M	3.74	3.61	3.94	4.42	4.16	4.14
	SD	1.34	1.02	1.47	0.77	0.97	0.98
Analyze an on-site soil profile to illustrate types of soil	M	3.63	3.55	4.08	4.34	4.38	4.00
	SD	1.36	0.96	1.35	0.83	0.80	1.03
List the macro and micro nutrients of soil	M	3.59	3.50	3.82	4.22	4.08	4.00
	SD	1.36	1.08	1.40	1.00	0.90	1.07
Distinguish between soil texture and structure	M	3.70	3.52	3.91	4.17	4.38	3.92
	SD	1.35	1.15	1.44	1.07	0.80	1.01
Explain soil alkalinity, salinity and acidity	M	3.63	3.61	3.85	4.37	4.30	3.92
	SD	1.33	1.02	1.43	0.84	0.85	0.99
Demonstrate the methods of soil conservation	M	3.66	3.88	3.97	4.48	4.50	4.00
	SD	1.24	1.03	1.38	0.81	0.70	1.03
Explain soil compaction	M	3.33	3.58	3.74	4.20	4.33	3.88
	SD	1.38	1.05	1.42	1.02	0.79	1.08
Demonstrate how to take soil samples and interpret soil test results	M	3.59	3.77	4.02	4.68	4.52	4.00
	SD	1.18	0.95	1.40	0.63	0.73	1.07
Demonstrate Cation Exchange Capacity of soil	M	3.22	3.44	3.65	3.91	3.94	3.55
	SD	1.12	1.05	1.34	1.06	0.79	1.15
Measure electrical conductivity and soil pH	M	3.03	3.36	3.82	3.63	3.86	3.77
	SD	1.06	1.09	1.31	1.11	0.96	1.08
List the environmental factors contributing to soil erosion	M	3.66	3.80	3.97	4.45	4.41	4.00
	SD	1.35	1.00	1.31	1.01	0.77	1.00
Explain soil erosion control measures	M	3.88	3.97	3.38	4.54	4.50	3.96
	SD	1.36	1.02	1.47	0.81	0.69	1.19

Table B-4. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Distinguish between conservation tillage and conventional tillage	M	3.55	3.77	3.82	4.40	4.36	3.96
	SD	1.12	1.01	1.40	1.06	0.86	1.19
Explain the biological properties of soil	M	3.70	3.58	3.85	4.02	4.27	3.63
	SD	1.29	0.99	1.30	0.98	0.91	1.18
Demonstrate the methods of maintaining water quality	M	4.00	3.91	4.05	4.37	4.47	4.00
	SD	1.14	1.05	1.02	0.94	0.69	1.27
Describe the principles of organic farming	M	3.11	3.25	3.57	3.94	4.41	3.66
	SD	1.15	1.02	1.22	1.25	0.95	1.20
Describe the importance of soil organic matter	M	3.51	3.77	3.77	4.31	4.33	4.07
	SD	1.15	1.07	1.28	0.93	0.86	1.26
Describe the cycle of soil ecosystem	M	3.59	3.33	3.62	3.65	4.08	3.81
	SD	1.18	0.95	1.21	1.18	0.93	1.21
Describe soil formation	M	3.22	3.36	3.74	3.97	4.11	3.63
	SD	1.34	0.89	1.33	1.20	0.91	1.27
Describe soil water availability	M	3.63	3.47	3.71	4.05	4.25	3.92
	SD	1.21	1.02	1.40	1.18	0.93	0.99
Demonstrate water holding capacity of soil	M	3.63	3.55	3.74	4.05	4.27	3.84
	SD	1.21	1.02	1.44	0.96	0.84	1.06
Develop pH scale to plot acidity and alkalinity	M	3.22	3.30	3.60	4.02	4.19	3.80
	SD	1.18	0.92	1.47	1.04	0.88	1.19
Identify pH ranges for major crops	M	3.22	3.47	3.39	4.02	4.25	3.06
	SD	1.36	1.03	1.27	0.97	0.98	1.35

Table B-5. Means and standard deviations for the degree to which instruction would be expanded in microbiology competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Demonstrate the operation of compound microscope	M SD	3.59 1.24	3.02 1.20	3.88 1.18	3.68 1.10	3.77 0.92	3.55 1.05
Describe the ways of classifying microorganisms related to agriculture	M SD	3.59 1.08	3.11 1.21	3.68 1.18	3.45 1.09	3.75 0.84	3.50 0.97
Distinguish between fungi and bacteria related to agriculture	M SD	3.70 0.95	3.05 1.09	3.85 1.14	3.68 1.01	3.80 0.82	3.59 0.93
Draw the structure of algae	M SD	2.88 1.18	2.58 1.10	3.17 1.15	3.22 1.06	3.55 1.05	3.11 1.25
Draw the structure of selected fungus in agriculture	M SD	2.88 1.21	2.61 1.12	2.94 0.99	3.11 1.15	3.50 1.05	3.11 1.18
Explain reproduction in fungi	M SD	2.77 1.12	2.61 1.12	3.02 1.04	3.20 1.32	3.58 0.96	3.37 1.11
Draw the structure of yeast	M SD	2.40 1.21	2.47 1.10	2.91 1.09	2.97 1.20	3.63 1.07	3.18 1.11
Observe the structure and composition of a bacteria under the microscope	M SD	3.00 1.14	2.69 1.26	3.54 1.44	3.34 1.21	3.69 1.03	3.44 1.12
Identify the difference between autotropic and heterotropic microbes	M SD	3.25 1.13	2.61 1.07	3.28 1.46	3.25 1.17	2.66 1.04	3.59 1.15
Identify the symptoms of major diseases of agronomic plants	M SD	3.70 0.91	3.38 1.27	3.82 1.13	3.91 0.98	4.19 0.78	4.07 1.03
List beneficial microbes in agriculture	M SD	3.66 0.87	3.27 1.18	3.82 1.27	3.68 1.15	4.00 0.86	4.03 1.09
Demonstrate culturing of micro-organisms in the laboratory	M SD	3.40 1.08	2.86 1.24	3.44 1.35	3.25 1.22	3.77 0.95	3.54 1.12

Table B-5. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Identify nitrogen fixing organisms and explain how they fix nitrogen	M SD	3.63 0.92	3.44 1.20	3.82 1.31	3.94 1.03	4.27 0.77	4.00 1.07

Table B-6. Means and standard deviations for the degree to which instruction would be expanded in food science competencies as perceived by vocational agriculture teachers in the U.S.A. (237)

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Describe the importance of yeast to man to agriculture products enhancement	M SD	3.29 0.82	3.25 0.91	3.22 0.91	3.40 0.81	3.97 0.97	3.70 0.82
Explain the microbial process that takes place during the preparation of bread	M SD	2.96 1.05	3.11 0.96	3.05 0.83	3.31 0.99	3.88 0.95	3.51 0.89
List the fungi used in the manufacture of cheese	M SD	3.91 1.15	3.00 1.13	3.68 0.99	3.45 0.98	4.22 0.98	3.55 0.89
Identify the fungi that spoils fruits and vegetables	M SD	3.29 1.10	3.25 1.27	3.42 0.73	3.57 0.94	4.25 0.99	3.63 0.79
Explain the process of conversion of feed into meat in hogs and cattle	M SD	3.66 0.87	3.97 0.98	3.94 0.80	3.91 0.74	4.52 0.65	4.07 1.03
Describe the process of milk formation in cattle	M SD	3.55 0.93	3.88 0.93	4.05 0.87	4.02 0.74	4.41 0.73	4.03 0.98
Explain how microbial activity in milk helps in the formation of milk products	M SD	3.29 1.17	3.54 0.95	3.88 0.86	3.80 0.83	4.36 0.76	3.81 0.68
Describe pasteurization of milk	M SD	3.63 1.11	3.54 0.95	3.94 0.90	4.14 0.81	4.30 0.74	4.07 0.67
Identify various food preservatives	M SD	3.25 0.98	3.42 0.94	3.86 0.99	3.88 0.83	4.16 0.84	3.92 0.67
Describe the process of fermentation	M SD	3.44 0.93	4.31 0.53	3.65 0.99	3.80 0.71	4.19 0.74	3.77 0.69
Demonstrate the laboratory preparation of vinegar	M SD	2.85 1.32	2.74 1.06	3.02 1.06	3.08 1.19	3.88 1.09	3.37 0.92

Table B-6. Continued

Competencies		Respondent groups					
		1 n=38	2 n=50	3 n=39	4 n=43	5 n=41	6 n=26
Explain the concept of food chain	M	3.59	3.97	4.11	4.17	4.41	3.74
	SD	1.15	0.74	0.79	0.78	0.64	0.85
Identify wholesale and retail cuts of meat	M	3.81	4.14	4.25	4.37	4.47	4.41
	SD	0.83	0.84	0.85	0.73	0.84	0.75
Explain the processing of milk and dairy products	M	3.51	4.10	4.17	4.18	4.33	3.96
	SD	0.97	0.83	0.95	0.78	0.79	0.85
Describe the various methods of processing fruits and vegetables	M	3.40	3.77	3.88	3.97	4.27	3.81
	SD	1.01	0.87	0.90	0.61	0.84	0.62
Explain the role of barley malt as a flavor supplement in baking	M	2.88	3.02	3.45	3.25	3.88	3.33
	SD	1.12	0.98	0.98	0.88	1.06	0.73
Explain how nutritive value of foodand feed grains can be improved through biotechnology	M	3.55	3.74	3.91	3.85	4.16	3.63
	SD	1.01	1.14	1.01	0.87	0.84	0.83
Identify some artificial sweetenershat can be manufactured in the industry using biotechnology	M	4.00	3.81	3.68	3.57	4.62	4.29
	SD	0.70	0.96	1.10	0.91	1.01	0.86

APPENDIX C. SURVEY PAGE

Centennial
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IOWA • STATE • UNIVERSITY
Agriculture & Home Economics
EXPERIMENT STATION

Department of Agricultural Education
201 Curtiss Hall
Ames, Iowa 50011
515-294-5872

Dear Vo. Ag. Instructor:

The need for infusion of biosciences into vocational agriculture is becoming a critical issue of discussion in agricultural education in the U.S.A. Applied agricultural sciences provide the framework for job opportunities. However, there is very little information about what is being taught and what more should be taught related to the biosciences of agriculture. Any amount of research in this area without your involvement would be a waste. Hence it was decided to conduct this survey to study the role of biosciences in agriculture as perceived by the vocational agriculture teachers in the U.S.A.

We are collecting information from vocational agriculture teachers around the nation. We hope that you will assist us in identifying the important bioscience knowledge and skills and the degree to which instruction in these areas can and should be expanded. Your response to this questionnaire is essential for developing instructional materials in the agriculture biosciences that will help students in acquiring occupations in the diverse agriculture industry of the present and future.

Your responses will be held in strict confidence and used for statistical purposes only. The code number assigned to the questionnaires will be used only to identify those who have not responded to the questionnaire so that we may contact them to encourage return of the questionnaire. Please be informed that you are free to withdraw your participation at any time during the project activity. We are interested in group data only. All instruments will be destroyed after the data is collected. We would appreciate your help in this study. We feel the information could assist us to develop the instructional materials teachers need to teach vocational agriculture in the coming decade and beyond.

Thank you for your assistance.

Sincerely,

Robert A. Martin
Associate Professor

V. Rajasekaran
Research Assistant

Department of Agricultural Education
Iowa State University
Ames, Iowa

SURVEY ON BIOSCIENCES

The Role of Biosciences in the Study of Agriculture as Perceived by the Vocational Agriculture Teachers in the U.S.A

Directions:

Listed below are a set of bioscience competencies thought to be important for instruction in agriculture in order to meet the growing needs of vocational agriculture students. It is thought with these competencies a number of activities could be developed to apply the knowledge and skills involved. You will find two blanks, one at the LEFT side and the other at the RIGHT side of each competency. On the left side, indicate the degree to which this competency is important as perceived by you. On the right side, indicate the degree to which you would expand instruction in that competency given needed materials and inservice. Use the scale below in order to express your perceptions.

If you feel that the competency is "highly important, write "5" on the left side of the blank. If you feel that the competency is not important, write "1" on the appropriate blank. Use any number between 1 to 5 in order to express your true feelings about the degree to which this competency is important.

While responding to the blank on the right side of the questionnaire, write "5" if you feel that you would certainly expand instruction in this competency area if needed materials and inservice are given. Write "1" if you feel instruction in this competency area is difficult and would be an unnecessary addition to the curriculum in spite of materials and inservice provided. Use any number between 1 to 5 to express the degree to which you would expand instruction in that competency given needed materials and inservice. Kindly respond to all items.

Please use the following two scales when responding to the degree of importance of each bioscience competency (left side) and the degree to which you would expand instruction in the competency (right side).

Degree of importance of bioscience competencies

§	§	§	§	§
1 Not important	2 Low importance	3 Moderately important	4 Highly important	5 Very highly important

Degree to which you would expand instruction in bioscience competencies.

§	§	§	§	§
1 No expansion	2 Low expansion	3 Moderate expansion	4 High expansion	5 Very high expansion

Example:

Degree to which this competency is important		Degree to which you would expand instruction in this competency given needed material and inservice
______	Explain gene splicing	______

Degree to which this competency/ knowledge is important (1 2 3 4 5)		Degree to which I would expand instruction in this competency / knowledge and given needed materials and inservice (1 2 3 4 5)

I. PLANT SCIENCES

Important	Competency	Expand
______	1. List the ways plants are classified.	______
______	2. Draw the internal structure of of leaves.	______
______	3. Conduct experiment for photo--synthesis and respiration.	______
______	4. Explain the function of roots.	______
______	5. Describe the internal structure of a stem.	______
______	6. Identify various modifications of a stem.	______
______	7. Draw the structure of a flower.	______
______	8. Describe the functions of each floral part.	______
______	9. Explain the process of pollination and fertilization.	______
______	10. Identify the modes of vegetative propagation in plants.	______
______	11. Demonstrate budding and grafting.	______
______	12. Explain the formation of fruits.	______
______	13. Describe the formation of seed.	______
______	14. Conduct a germination experiment to show the stages of germination of seeds.	______
______	15. Dissect a plant and name the parts.	______
______	16. Identify important weeds of crop plants.	______
______	17. Demonstrate the foliar application of nutrients in plants.	______
______	18. Demonstrate the practice of hydro-ponics.	______
______	19. Explain the principle of stock selection in plants.	______
______	20. Explain the importance of apical meristem in growth.	______
______	22. Demonstrate the process of uptake of water and nutrients by plants.	______
______	23. Describe how nitrogen fixation takes place in leguminous crops.	______
______	24. Demonstrate the effect of growth hormone on the rate of sprouting of vegetatively propagated plant.	______
______	25. Record through observation the development of a plant.i.e., corn soybean,tomato etc.,	______
______	26. Explain short night and long night plants.	______
______	27. Identify some plant growth regulators.	______
______	28. List the limiting factors of plant growth.	______
______	30. Demonstrate the selective action of herbicides.	______

List others if any:

Important	Competency	Expand
______	31.	______
______	32.	______

II. GENETICS

Important	Competency	Expand
______	33. Distinguish between a plant and an animal cell.	______
______	34. Take a cross-section of a plant part and observe the cell through the microscope.	______
______	35. Draw a plant cell and an animal cell.	______
______	36. Describe the function of DNA.	______
______	37. Explain the process of gene splicing.	______
______	38. Describe the process of tissue culture.	______
______	39. List various plant breeding techniques.	______
______	40. Explain the advantages of plant improvement.	______
______	41. Describe the cloning of genes.	______
______	42. Describe how mutation takes place in plants.	______
______	43. Explain the formation of recombinant DNA.	______
______	44. State Mendel's law of inheritance.	______
______	45. Explain the process of gene insertion into germ cell lines.	______
______	46. Describe the process of natural selection of plants.	______

______ 47. Enumerate the difference between traditional plant breeding methods and modern gene splicing. ______

______ 48. Describe the advantages of gene splicing over the traditional plant breeding methods. ______

______ 49. Explain the role of monoclonal anti-*bodies for progeny testing.* ______

______ 50. Explain the process of transgenesis. ______

______ 51. Describe the role of gene splicing in the production of bovine and porcine somatotropin. ______

______ 52. Distinguish between in-breeding and out-breeding in animals i.e., beef, swine and dairy. ______

______ 53. List the *methods of breeding in swine.* ______

______ 54. List the criteria for selecting breeding stock. ______

______ 55. Explain the process of embryo transfer ______

______ 56. Explain the principle of developing disease and pest resistant crop varieties using genetic engineering. ______

______ 57. Describe gene expression. ______

List others, if any:

______ 58. ______

______ 59. ______

III. ANIMAL SCIENCES

______ 60. Identify classification of livestock species. ______

______ 61. Draw the digestive system in ruminant and monogastric animals. ______

______ 62. Calculate balanced feed ration. ______

______ 63. Explain the role of bovine growth hormone in milk production. ______

______ 64. Describe the composition of meat and and milk. ______

______ 65. Draw the reproductive system of selected animals. ______

______ 66. Demonstrate the procedure of artificial insemination. ______

______ 67. List the factors for selection of animal breeds. ______

______ 68. Describe the symptoms of major animal diseases. ______

______ 69. Outline the procedures to control animal diseases. ______

______ 70. Explain the principle of immunization in animals. ______

______ 71. Demonstate the use of vaccines against major animal diseases. ______

______ 72. Describe the principle of sex linkage in animals. ______

______ 73. Analyze the ingredients of selected animal products. ______

______ 74. Explain how cycling time can be *increased in animal production.* ______

______ 75. Explain the function of endocrines in animals. ______

______ 76. Explain the physiology of lactation, egg production and meat production in animals. ______

List others, if any:

______ 77. ______

______ 78. ______

IV. SOIL SCIENCE

______ 79. Describe the nature and properties of soil. ______

______ 80. Analyze an on-site soil profile to illustrate types of soil. ______

______ 81. List the macro and micro nutrients of soil. ______

______ 82. Distinguish between soil texture and structure. ______

______ 83. Explain soil alkalinity, salinity and acidity. ______

______ 84. Demonstrate the methods of soil conservation. ______

______ 85. Explain soil compaction. ______

______ 86. Demonstrate how to take a soil sample and interpret soil test results. ______

______ 87. Describe cation exchange capacity of soil. ______

______ 88. Measure electrical conductivity and soil pH. ______

______ 89. List the environmental factors contributing to soil erosion. ______

______ 90. Explain soil erosion control measures. ______

______ 91. Distinguish between conservation tillage and conventional tillage. ______

______ 92. Explain the biological properties of soil. ______

______ 93. Demonstiate the methods of maintaining water quality. ______

_____ 94. Describe the principle of organic farming. _____
_____ 95. Describe the importance of soil organic matter. _____
_____ 96. Draw the cycle of soil ecosystem. _____
_____ 97. Describe soil formation. _____
_____ 98. Determine soil water availability. _____
_____ 99. Demonstrate the waterholding capacity of soil. _____
_____ 100. Develop pH scale to plot acidity and alkalinity. _____
_____ 101. Identify pH ranges for major crops. _____

List others, if any:

_____ 102. _____

_____ 103. _____

V. MICRO-BIOLOGY

_____ 104. Demonstrate the operation of the compound microscope and explain its relationship in agricultural science. _____
_____ 105. Describe the ways of classifying microorganisms related to agriculture. _____
_____ 106. Distinguish between fungi and bacteria related to agriculture. _____
_____ 107. Draw the structure of algae. _____
_____ 108. Draw the structure of a selected fungus in agriculture. _____
_____ 109. Explain reproduction in fungi. _____
_____ 110. Draw the structure of yeast. _____
_____ 111. Observe the structure and composition of a bacterial cell under the microscope. _____
_____ 112. Identify the difference between autotropic and heterotropic microbes. _____
_____ 113. Identify the symptoms of the major diseases of agronomic plants. _____
_____ 114. List beneficial microbes in agriculture. _____
_____ 115. Demonstrate culturing of microorganisms in the laboratory. _____
_____ 116. Identify nitrogen fixing organisms and explain how they fix nitrogen. _____

List others, if any:

_____ 117. _____

_____ 118. _____

VI. FOOD SCIENCE

_____ 119. Describe the importance of yeast to man to agriculture product enhancement. _____
_____ 120. Explain the microbial process that takes places during the preparation of bread. _____
_____ 121. List the fungi used in the manufacture of cheese. _____
_____ 122. Identify the fungi that spoil fruits and vegetables. _____
_____ 123. Explain the process of conversion of feed into meat in hogs and cattle. _____
_____ 124. Describe the process of milk formation in cattle. _____
_____ 125. Explain the microbial activity in milk and how it helps in the formation of milk products. _____
_____ 126. Describe pasteurization of milk. _____
_____ 127. Identify various food preservatives. _____
_____ 128. Describe the process of fermentation. _____
_____ 129. Demonstrate the laboratory preparation of vinegar. _____
_____ 130. Describe how vinegar is used in the manufacture of canned beverages. _____
_____ 131. Explain the concept of food chain. _____
_____ 132. Identify wholesale and retail cuts of meat. _____
_____ 133. Explain the processing of milk and dairy products. _____
_____ 134. Describe the various methods of processing fruits and vegetables. _____
_____ 135. Explain the role of barley malt as a flavor supplement in baking. _____
_____ 136. Explain how nutritive value of food and feed grains can be improved through biotechnology. _____
_____ 137. Identify some artificial sweeteners that can be manufactured in the industry using biotechnology. _____

List others, if any:

_____ 138. _____

_____ 139. _____

Part II

Perceptions Regarding Biosciences in Agricultural Education

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

Please use the following scale to express your agreement.

5 - Strongly Agree
4 - Somewhat Agree
3 - Neutral
2 - Somewhat Disagree
1 - Strongly Disagree

	Statement	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
1.	Infusion of biosciences is essential for the study of vocational agriculture.	5	4	3	2	1
2.	Learning basic sciences would help students to better understand agricultural sciences.	5	4	3	2	1
3.	Students should learn how to explain the processes that occur in plants and animals while learning biosciences.	5	4	3	2	1
4.	Infusion of more of the biosciences would expose students to diversified career opportunities such as biotechnology.	5	4	3	2	1
5.	Learning about the biosciences would help students in solving problems in the real world.	5	4	3	2	1
6.	Learning about the biosciences help will students in developing skill in the related agriculture fields.	5	4	3	2	1
7.	Students are interested in learning the biosciences as they are related to agriculture.	5	4	3	2	1
8.	I am interested in relating bio-science skills and knowledge to agriculture.	5	4	3	2	1
9.	It takes additional time for the Vo. Ag. teacher to incorporate biosciences into the study of agriculture.	5	4	3	2	1
10.	Additional instructional materials are required for infusing the biosciences into the study of agriculture.	5	4	3	2	1
11.	The infusion of the biosciences into vocational agriculture would strengthen FFA activities.	5	4	3	2	1
12.	Basic agriculture sciences would help in developing Supervised Occupational Experience programs.	5	4	3	2	1
13.	Biotechnology can be used to increase yields and cost inputs.	5	4	3	2	1
14.	Biotechnology can be used to reduce dependency on environmentally undesirable chemicals.	5	4	3	2	1
15.	With biotechnology, plant breeders will be able to get desired results with greater speed and precision.	5	4	3	2	1
16.	Biotechnology will be useful for improving disease and insect resistence of plant varieties.	5	4	3	2	1
17.	Biotechnology will help breeders to improve nutritive values of food and feed grains.	5	4	3	2	1
18.	Biotechnology will help develop new uses for crops and livestock products.	5	4	3	2	1
19.	Biotechnology will promote chemical dependency.	5	4	3	2	1

Part III
Demographic Data

Directions: Please respond to the following questions by checking the appropriate answers or filling in the blank to describe your present characteristics.

1. In which of the following NVATA regions are you now serving as a vocational agriculture teacher?

   Region I ________
   Region II ________
   Region III ________
   Region IV ________
   Region V ________
   Region VI ________

2. How many teachers of vocational agriculture are there in your department?

   ________ One
   ________ Two
   ________ Three
   ________ Four
   ________ Five or more

3. How many years of experience do you have in teaching vocational agriculture?

   Number of years ________

4. Check the educational level attained by you.

   ________ B.S.
   ________ M.S.
   ________ Ph.D.

5. What is your age?

   ________ Years

6. How many students are enrolled in your vocational agriculture program?

   Number of students ________

7. What percent of your total work load is related to FFA activities?

   ________ percent

8. Are you involved in young farmer education?

   Yes ______
   No ______

   If yes, please specify the number enrolled

   ______

9. Do you conduct any other adult education program?

   Yes ______
   No ______

10. What percent of your vocational agriculture students are actively participating in supervised occupational experience programs?

    Percent of students ________

11. Please specify any other professional responsibilities you have in additiion to the above.

    ____
    ____

12. Comments, if any:

    ____
    ____
    ____
    ____

Please return to:
Dr. Robert A. Martin
Associate Professor
217 B, Curtiss Hall
Iowa State University
Ames, IA. 50011

1·8·8·8 Centennial 1·9·8·8
IOWA • STATE • UNIVERSITY
Agriculture & Home Economics
EXPERIMENT STATION

Department of Agricultural Education
201 Curtiss Hall
Ames, Iowa 50011
515-294-5872

Date: June 28, 1988

To: Bioscience in Vo. Ag.
Survey Participant

From: Robert A. Martin

A few weeks ago you were sent a questionnaire regarding the teaching of the biosciences in vocational agriculture. Many people have returned their questionnaires and we sincerely appreciate that. However, there are some who have not yet returned the survey questionnaire as of this date. We know this is a busy time for you, but we would appreciate your response to the survey. For the study to be successful we need your input.

If you have already returned the questionnaire, please disregard this memo. If you have not returned the questionnaire, may we please hear from you in the near future?

Thanks for your assistance.

bjo

Time is running out!!
Please help us to help you!!

Have you mailed your questionnaire related to "Infusion of Biosciences into Vocational Agriculture" that will help students in acquiring skills and knowledge in the diverse agricultural industry?

Because your response is very essential to continue the study, would you please complete the questionnaire within the next three days and mail it to us?

Thank you very much.

Sincerely,

Robert A Martin
Associate Professor
515-294-0896

B. Rajasekaran
Research Assistant
515-294-0901

Dr. Robert A. Martin,
Associate Professor
217 B Curtiss Hall
Department of Agricultural Education
Iowa State University
Ames, Iowa 50011

To: