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ABSTRACT

This report is one of seven that identify major new and emerging technological advances expected to influence major vocational education program areas and to describe the programmatic implications in terms of skill-knowledge requirements, occupations most directly affected, and the anticipated diffusion rate. Chapter 1 considers technology as process, the relation of technology and productivity, and technology as the arbitrator of work. The first of three sections in chapter 2 presents the procedures used to identify and clarify the most innovative, new, and emerging technologies with implications for vocational education. Brief descriptions of the technologies expected to affect vocational agricultural occupations are included in section 2. Section 3 contains 12 essays describing these new and emerging technologies with implications for vocational agricultural occupations: animal production, aquaculture, micropropagation of plants with preplanned genetic characteristics, soil-less plant propagation--nutrient film technique, personal computers, microelectronic monitors and controls, agricultural machinery and equipment, planting methods and equipment, conservation tillage, drip or trickle irrigation, renewable energy technologies, and integrated pest management. Chapter 3 is an annotated bibliography with citations descriptive of new or emerging technologies, their diffusion, or insights as to their vocational implications. (YLB)

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TECHNOLOGIES OF THE '80s: THEIR IMPACT ON VOCATIONAL AGRICULTURE OCCUPATIONS

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FOREWORD

Productivity is a critical economic concern. Sagging productivity growth coupled with rising costs and heightened foreign competition are placing American business and industry in an increasingly vulnerable position. In an effort to strengthen its competitive position, American business and industry is investing heavily in capital-intensive technology. However, productivity is people-dependent and its improvement conditioned upon their possessing the technical and organizational skills necessary to utilize technology to its fullest advantage. The development of the work skills required to contribute to the revitalization of America is the central challenge to vocational education.

This report is the result of a contract with the U.S. Department of Education, Office of Vocational and Adult Education to investigate the changing role of vocational education resulting from new and emerging technologies. It identifies the major technological advances expected to influence each of the major vocational education program areas and describes the programmatic implications in terms of skills-knowledge requirements, the occupations most directly affected and the anticipated diffusion rates.

An associated project report, "Working for America: A Worker-Centered Approach to Productivity Improvement," is devoted to an examination of worker-centered productivity and a discussion of the organizational and educational strategies for its improvement. A companion monograph entitled "Vocational Education: Its Role in Productivity

Improvement and Technological Innovation" describes the relationship between productivity and technology and presents mechanisms for state vocational education agency use in productivity improvement and technological innovation.

Technologies described in this paper range from the "hard" technologies with industrial applications, (e.g, robotics and computer-assisted design and manufacture), to "soft" technologies such as alternative work scheduling; (e.g., flexitime, job-sharing); or worker participation in management; (e.g., quality control circles, quality of life groups). Both "hard" and "soft" technologies can be expected to bring rapid and radical change to workers involved in their use. Some technologies may affect only one vocational education instructional area. The effects of other technologies will be felt in several or all of the vocational education instructional areas in varying degrees. In either case, vocational educators must take action to assure the inclusion of the skills demanded by these technologies in their instruction in order to meet the job challenges of the near future.

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CHAPTER I

TECHNOLOGY--THE FORCE FOR CHANGE

TECHNOLOGY AS PROCESS

Technology means many things to many people. Some see technology as the driving force propelling society into the future. Others view it as evidence of an engulfing mechanistic materialism that threatens to destroy our humanistic values. Workers fear that technological advancements will take away their jobs and render their skills obsolete.

All of these are in part true. Undoubtedly, technology influences the future growth and direction of society. Technology is mechanistic and may be used to the detriment of human dignity. Indeed, technological advancements do render certain job skills obsolete. These conditions, however, speak more to the results of technology than to the nature of technology itself.

Technology in essence is the application of information, techniques and tools to material resources so as to achieve desired ends. At the societal level, these desired ends translate into a mix of material goods and services required to satisfy society's wants. Technology provides the ways and means for producing the desired stock of goods and services. Since production implies the use of resources to create products of value, technology provides the means to convert natural resources into material wealth.

Technology, then, can be regarded in the abstract as the process used by a work system to convert inputs into outputs. A work system can be defined as any organization that expends energy (work) to convert resource inputs into outputs in the form of goods and services. Work systems may be defined at any level from society as a whole to a work group at the department or subdepartment level of firms and organizations.

The notion of a work system as an input/output system is shown in Figure 1.

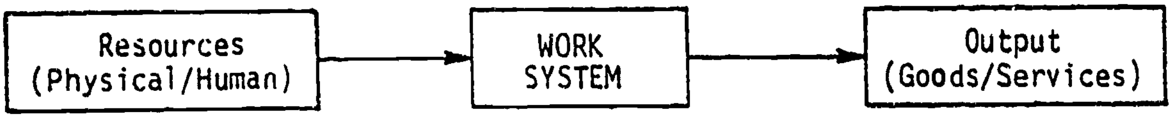

Figure 1. Input/Cutput Model

As indicated, inputs enter the work system, work in the form of energy expended is performed, and inputs are translated into outputs in the process. The process or rule for translating inputs into outputs is in the essence what is meant by technology. Thus, for any work system, the prevailing technology determines what outputs will be produced as a function of inputs. In the most general sense, technology can be regarded as an input/output function. Technology is not to be equated to either the inputs nor the output products of the work system. Rather, technology is the correspondence rule that determines the outputs resulting from a specific level of input.

Inputs into a work system are the resources used in the process of production. These resources in the most general sense are labor, capital, materials and energy which are frequently referred to as the factors of production. Output of a work system is measured in terms of goods and/or services produced. Using these definitions of input and output, technology can be regarded as the function that maps or transforms the factors of production into goods and/or services produced. In economic terms, this function is called a production function and expressed as:

Technology = Production function

= F(labor, capital, materials, energy)

Technology, considered as a production function, constrains the way the factors of production combine to produce an output of goods and/or services. For example, technology as process determines the unique contribution of each factor of production with the other factors held constant and determines the impact of substituting one factor for another. Factor substitution occurs when one factor such as capital is used in increasing amounts as a substitute for another factor, such as labor. The important point is that it is the current technology that determines how the factors are inter-related and the relative output contributions of each factor.

Suppose now that an increase in the output of the work system was observed even though all factors of production were held constant. The only way this could occur would be for the production function itself to change. Since technology is equated with the production function, this is defined as technological change. Technological change occurs when efficiencies in the production process allow for increased output without the necessity for more input resources to be used. Thus, if a change in output accrues from training workers to work smarter, but not harder, then a technological change can be said to occur, provided that the increase resulted from more output per unit of labor expended rather than more units of labor being expended (working harder). In a similar manner, technological change can result from any alteration in the production process that results in more output per unit of factors of production used.

Typically, technological changes result from the introduction of labor saving devices. These devices, in the form of equipment and/or tools, make it possible to glean increases in output per hour of labor input. The effect is to alter the production function so as to reflect the increased contribution of labor to production output. Technological change can also result from changes in the managerial and work structure that result in improved output contributions from one or more factors of production. Because of the multitude of sources, the technology of a work group is in a continual process of change. Thus, technology evolves through incremental changes as the work system seeks to fine tune the process through improved production efficiencies.

Periodically, conditions arise that substantially alter the organization of work systems. Responsiveness to these conditions requires that the work systems, to survive, must adopt a new production function. Production functions that differ in form are termed technological innovations and are to be differentiated from technological changes. Whereas technological change is associated with incremental evolutionary changes in the production function, technological innovation signals a discrete shift from one form of production function to another. This discrete break with the past generally is associated with the introduction of a revolutionary new process that allows resource inputs to be combined in an unprecedented manner. An example is the cotton gin, which dramatically decreased the time necessary to remove unwanted material from usable cotton fiber. The impact of these and other significant inventions is to recombine the factors of production in a totally new and significantly more productive fashion. Thus, whereas technological change is evolutionary, technological innovation tends to be revolutionary in its effects.

TECHNOLOGY AND PRODUCTIVITY

Productivity of a work system is typically defined as the ratio of system outputs to system inputs. Productivity increases when more outputs are produced per unit of input. Increased productivity makes possible an increased amount of goods and services per unit of factors of production used and results in an improved standard of living, increases in real income and strengthened price competitiveness. For an expanded discussion of productivity, see the companion project report "Working For America--A Worker-Centered Approach to Productivity Improvement" (CONSERVA, 1982).

The relation of technology and productivity flows from an examination of the definitions of the two concepts. Productivity of a work-system can be defined for all factors of production used simultaneously, or each individual factor of production can be considered separately.

(a) Total Factor Productivity = $\frac{\text{Work System Output (goods/services)}}{\text{Total Resources Used (labor, capital, materials, energy)}}$

(b) Labor Productivity = $\frac{\text{Work System Output (goods/services)}}{\text{Labor Resources Used}}$

(c) Capital Productivity = $\frac{\text{Work System Output (goods/services)}}{\text{Capital Expended}}$

(d) Materials Productivity = $\frac{\text{Work System Output (goods/services)}}{\text{Materials Used}}$

(e) Energy Productivity = $\frac{\text{Used System Output (goods/services)}}{\text{Energy Consumed}}$

Recall that technology was defined as the production function F(labor, capital, materials, energy). Whereas technology is the function itself, a specific output corresponding to an input of L-units of labor, C-units of capital, M-units of materials, and E-units of energy is dictated by the technology and designated as f(L,C,M,E). By substituting for the output, the productivity definitions can be rewritten as:

(a) Total Factor Productivity = $\frac{f(L,C,M,E)}{L+C+M+E}$

(b) Labor Factor Productivity = $\frac{f(L,C,M,E)}{L}$

(c) Capital Productivity = $\frac{f(L,C,M,E)}{C}$

(d) Materials Productivity = $\frac{f(L,C,M,E)}{M}$

(e) Energy Productivity = $\frac{f(L,C,M,E)}{E}$

Technological change influences the productivity of all factors of production by altering the value of the production function f(L,C,M,E). If the change in technology results in a positive increase, then productivity will also increase accordingly. The explanation is that technological change makes possible increased outputs of goods and services without a corresponding increase in resources used. This increase in the stock of goods and services available is translated into an increase in the standard of living as more wealth is available for distribution. An expanded standard of living creates demand for additional products and services which provides work for more people. Additionally, increased productivity allows goods and services to be priced more competitively since increased productivity lowers per unit production costs. Price stability is beneficial in that it is anti-inflationary and contributes to our ability to compete on the international market.

TECHNOLOGY AND WORK

Technology is the great arbitrator of work. It is technology that specifies how capital goods can be used by workers to convert raw materials into finished products. It is technology that determines the range of human skills and abilities necessary to use the capital goods as production tools. It is technology that specifies the appropriate materials for which the tools can be used and the energy required for their use.

Whereas technology sets the stage and writes the script, it is management that directs the production. Management's decisions determine the desired mix of labor and capital, the rates at which labor and capital will be utilized, the quantity of labor, capital and materials used and the extent of substitutability between elements of labor, capital and energy. It is also management's responsibility to maintain a management climate that facilitates the most efficient and coordinated use of labor and capital. For a discussion of the impact of management climate on productivity and suggested strategies for development of a worker-centered approach to productivity, see the companion project report "Working for America--A Worker-Centered Approach to Productivity Improvement," Chapter III, (CONSERVA, op. cit).

Innovations incorporated in new capital goods tend to spearhead technological change and innovation. The latest advances in knowledge and theory tend to be embodied in the design and structure of new capital equipment. Innovations and capital goods design have direct implications for labor as a factor of production.

These implications affect not only the human skills requirements, but also the very organization of work itself. Human skills requirements may be relatively unchanged in those cases where new advancements were made without basically altering the production process. A typical example might be the development of a new type of herbicide. In this case, the advancement could be basically incorporated into the existing process and would require minor alterations in human skills requirements. Contrast now the detailed planning and scheduling of activities, some of which were formerly ignored altogether, that comprises a program of integrated pest management. In this example, the very organization of work itself has been drastically changed with consequent changes in the nature and intensity of human skills requirements. This represents a dramatic illustration of the distinction to be drawn between technological change and technological innovation.

The press for technological innovation is strong and mounting in intensity. Productivity growth is sagging in the country, having fallen from an average annual rate of increase 3.1 percent in the period 1948-58 to a mere 0.7 percent for the period 1974-81. (Statement of the Chamber of Commerce of the United States on Productivity, April 2, 1982). There is near universal agreement that the lack of capital has been one of the major causes of this decline. As Lester Thurow, a noted expert on productivity, states,

> The amount of equipment per worker--the capital-labor ratio--is a key ingredient in productivity growth. Better-equipped workers can produce more output per hour, but new capital is also a carrier of new technologies. To put new, more productive technologies to work, workers must be provided with the equipment that embodies those new technologies. Without this additional hardware, or "physical capital," it is impossible to translate new knowledges into new output (Technology Review, November/December 1980, page 45).

In the area of foreign trade, the United States is in the process of moving from being a net exporter to a net importer in major categories of industrial output. As shown by a study recently conducted by the Department of Labor, of the top 17 U.S. export commodities, losses in the world market were experienced in 14 of the commodities. Between 1962 and 1979, the U.S. trade position had deteriorated such that market losses had been experienced in all 17 of the top export commodities. (Congressional Hearings, December 1980 and January 1981).

The report attributed the decline in U.S. international competitiveness to changing supplies of world resources and diminished technological capabilities. The rate of growth of the capital-labor ratio, a measure of the amount of capital available per worker, declined to such an extent that the United States fell from first to sixth in terms of capital available per worker. The United States' share of world capital fell from 42 percent in 1963 to 33 percent in 1975. During the same time, Japan doubled its capital from 7 to 15 percent of the world's share. As the U.S. stock of physical capital fell, so did its human capital. According to Department of Labor analyses, the United States fell from second to seventh in terms of percentage of skilled workers in the labor force-with the U.S. share of skilled workers falling from 29 percent to 26 percent. (Congressional Hearings, December 1980 and January 1981, op. cit.).

As a compounding problem, the United States is reported to be experiencing a severe shortage in skilled labor. In a widely quoted report, the Department of Labor projects average annual training shortfalls in excess of 250,000 persons per year for the next decade (U.S. Department of Labor, 1980). These are regarded as minimum estimates since they result from inclusion of only the 13 occupations with the greatest projected shortages. The Task Force on the Skilled Trade Shortages, which represents a coalition of 13 metalworking industries, estimates an anticipated need for 240,000 journeyworkers in the metal trades by 1985. (America's Skilled Trade Shortage: A Positive Response, 1981). The American Electronics Association, in a survey of its members, projects a need over the next five years for approximately 113,000 technical professionals in eight job categories and an additional 140,000 technical paraprofessionals in 13 job categories. (Shortages in Skilled Labor, November 3, 1981).

America stands at an economic crossroad. In the face of impending labor shortages, American business and industry can follow one of two major courses--one will be business as usual. If that philosophy prevails and a labor shortage materializes, per unit labor costs can be expected to increase, leading to increased prices as businesses seek to maintain their profit picture. Continued sluggishness in capital investments, coupled with the shortage of skilled labor, will dim any prospects for productivity improvements. As a result, inflation can be expected to escalate, our standard of living to diminish, our foreign competition to increase, and the United States will be well on its way to becoming a second-rate power.

As an alternative, the United States can make a significant investment in labor-saving capital in an effort to reverse the productivity trends and to regain the competitive edge. If the strategy is undertaken with vigor, the implications can be profound. Unlike the early '60s when the concern for the effects for technology proved to be unfounded, the United States currently stands on the brink of a technological revolution drawing its force from the emergence of the microprocessor and its ubiquitous applications. Agricultural machinery incorporating microelectronics technology has the potential to increase manyfold the efficiency of harvesting and processing agricultural products.

America is rapidly shifting from a manufacturing to a service-based economy. In 1950, nearly one out of three non-agricultural work ers was employed in manufacturing, and only one out of eight employed in services. By 1980, only 22 percent of the non-agricultural work force was in manufacturing as opposed to nearly 20 percent in services. In terms of percent change in employment for the three decade period, manufacturing increased a scant 33 percent in contrast with a 231 percent increase for services (Impact of Technological Change, 1981). The shift is being experienced both in international as well as domestic markets. While we are becoming a large net importer of manufactured goods, the United States now exports about $60 billion worth of services a year. This qualifies the United States as the largest exporter of services in the world, exporting nearly 25 percent of the world's service base. (Presentation of Dr. David L. Birch to the Council of Upper Great Lakes Governors, March 5, 1982). As a consequence of our changing service base, capital investments to facilitate handling and communication of office information can be expected to increase. New capital innovations can be anticipated in the areas of advanced word processors, electronic methods of reproduction and transmission of images and other electronically-augmented telecommunication devices.

The impending technological revolution will not be expected to be entirely bloodless. The transition from a manufacturing to a service economy can be expected to have severe short-run implications for those whose skills have become obsolete because of changes in technological demands. Whereas job displacements may be regarded as but minor perturbations in society's overall growth, they represent crises of major proportion in the lives of those who are experiencing them. In order to ease the transition and to contribute to the more effective and best productive use of our human resources, it is incumbent that quality skills training be provided that is attuned to the demands of emerging technology needs and available to all those who can profit from its exposure. The extent to which vocational education rises to meet these needs will determine the contribution that vocational education makes to the revitalization of the economy and the continued prosperity of society.

CHAPTER II

NEW AND EMERGING TECHNOLOGIES

Vocational education to be responsive to the demands of forthcoming technology must become increasingly aware of the nature of these technologies and their associated training requirements. In recognition of this need, CONSERVA, Inc. was awarded a contract by the U. S. Department of Education to identify the most innovative, new or changing technologies and to assess their occupational implications for specific vocational education program areas. The procedures used to identify and clarify technologies are presented in the first section. Brief descriptions of the identified technologies are included in the second section. Cameo reports describing the major new and emerging technologies with implications for Vocational Agriculture occupations are provided in the third section.

IDENTIFICATION AND SELECTION PROCEDURES

In order to identify new or changing technologies with implications for vocational education, project staff reviewed recent years' issues of several hundred different business, trade/industrial, and technical periodicals seeking information concerning technological change or its impact.

In reviewing published articles for possible relevance, three basic characteristics were considered. First, there must have been evidence that the technology is currently being used in the "real world"--i.e., that it is not still "on the drawing board" or futuristic. Second, the technology must have appeared to have direct or indirect implications for the way work is performed, and must impact skills within the training domain of vocational education. Finally, trend projections or other indications were sought as evidence that the technology was being increasingly used, implying greater numbers of jobs affected and resulting importance to vocational educational programming.

Having identified a set of technologies which are new or emerging, which promise growth, and which appear to impact job training, project efforts focused on the possible vocational implications of the technology. The implications were defined in terms of job activities affected, knowledges and skills required to carry forward these job activities, and special equipment or facilities (cost considerations) which might be necessary to instruct vocational students in the technology.

As a means of obtaining technology-specific information, outside experts were sought whose backgrounds and performance records qualified them to speak with authority about specific technologies and their training implications. For each of the identified technologies within a specified vocational education program area, a knowledgeable individual was invited to author a brief, nontechnical essay oriented to vocational education.

Since certain technologies have rather broad occupational implications, authors were allowed discretion as to which occupations or tasks they would emphasize. In making their decisions, authors were requested to consider the developing technology from a training and instructional perspective. Specifically, authors were asked to address the following areas:

- Work activities which involve the technology --

  The kinds of major duties or activities that may be new, changing, or developing as a result of the new or changing technology, with reference to the occupations under discussion.

- Knowledges and skills essential or important for productive completion of such activities --

  Knowledges are awareness of facts and process details, understanding of principles, etc., and "skills" are "hands on" abilities actually to carry out functions. The knowledges and skills to be covered were to relate to the work activity demands of the new or developing technology.

- Special equipment or facilities that would be required to teach such knowledges and skills --

  Aside from books, other usual instructional media, and standard educational facilities, any special devices (e.g., simulators or prototypes) or other capital that might be needed for instruction in identified knowledges or skills.

- Growth and trends in the diffusion or expansion of the technology --

  Observations of recent growth, and projections concerning likely near future expansion, of the technological innovations or changes, in business/industry/other applications that involve occupations under discussion.

TECHNOLOGIES EXPECTED TO IMPACT VOCATIONAL AGRICULTURE OCCUPATIONS

Technologies selected for inclusion are those determined by application of the criteria to have programmatic implications for Vocational agriculture occupations. Brief descriptions are presented below. The purpose of these descriptions is to generally and summarily define the technologies being discussed by the experts.

By Microelectronic Monitors and Controls is meant those components of larger systems which may automatically control parts of the larger system, or which can monitor and display to human operators indications of what's going on within the system and transmit operators' instructions to the system. New graphics, voice recognition and synthesis, and sensor capabilities are among the advances in this technology area.

Microcomputers or Personal Computers, also called "desktop" computers, are by now somewhat familiar to us all. Small-sized and affordable by comparative standards ($5,000 or less will buy a sophisticated system), these machines incorporate many of the logical capabilities of larger computers and can be programmed to perform many of the same sorts of tasks. This is made possible by microprocessor technology. Microprocessors, based on large and very large scale integrated circuits, have sometimes been called "computers-on-a-chip." Microprocessors are used not only in microcomputers but in many other "hardware" systems which can then perform computer-like functions.

Animal Production is a diverse and changing field. New and improved systems and techniques in the general care and husbandry of animals, applied animal agriculture, agriculture disciplines that support animal production, and applications of biological sciences involved in such activities demand new and changing skills and training.

Integrated pest management (IPM) is a unified, conservation-oriented approach to the control of animal and plant pests in agricultural endeavors. It involves optimal co-use of different chemical, biological, and ecological control methods, with an eye toward long-range impact and cost control.

Micropropagation of Plants With Pre-planned Genetic Characteristics refers to the use of tissue culture systems for mass propagation of selection plants by cloning or asexual reproduction. Mass production of new plants may arise from a single cell through miosis or division from leaf stem or root cuttings, meristems, runners or stem tips. Systems of mass propagation may be economical and a unique means of propagating improved disease-free specimens.

Soil-less Plant Propagation-Nutrient Film Technique refers to systems and techniques for producing high value crops or plants without using soil as a rooting substrate. This can be accomplished by hydroponics or soil-less culture, or by using a variety of substrates other than soil.

Conservation Tillage is a technology in which the residue of the previous crop is left as a surface much through which the new crop is seeded, and weed control is effected by appropriately applied chemical herbicides. It is the most effective soil management practice yet devised as an erosion preventative and is becoming increasingly important for the conservation of soil, water, soil organic matter, and in the use of fossil energy.

Renewable energy technologies (RETs) are receiving renewed emphasis and application. Sources or methods for the production of usable energy such as solar, wind power and biomass conversion are being studied and implemented in agricultural, architectural and other settings as economic, conservation, and/or fuel-saving measures.

Following the rapid advancements in horsepower and operator convenience made in the last decade, Agricultural Machinery and Equipment is undergoing even further changes brought about by widespread applications of electronics and computer technology. Many pieces of machinery or equipment will be loaded with sensors, monitors, relays and even on-board computer systems that will enhance efficiency, cut crop losses, and save energy.

A blending of electronics and computers will soon make a critical impact on Planting Methods and Equipment. Improvements in planters and seeders will make possible precise seeding depth and spacing and adjustments by the operator in planting patterns to varying conditions even within the same field. New seeding, fertilizing and pesticide application methods are called for with the advent of conservation tillage practices such as low-till or no till.

Aquaculture embodies those methods and systems for the recent improvement and expansion of the age-old technology of raising aquatic plants and animals in natural or man-made bodies of water as a commercial venture. Included in the "crops" are many varieties of fish (trout, catfish, salmon, etc.) and shellfish or seafood (shrimp, lobsters, oysters, etc., or plants such as an algae (used for cattle food) and water chestnuts, etc.

Drip or trickle irrigation refers to the type of irrigation system in which, through a series of automatically-controlled surface or subsurface water lines and outlets called emitters, water and other water soluble materials such as fertilizers, fungicides and insecticides can be applied directly to the plants, with considerable application cost savings.

TECHNOLOGY ESSAYS

The following essays describe the new and emerging technologies identified as impacting Vocational agriculture occupations. The essays, while edited for consistency, remain basically the products of their authors. Sincere appreciation is expressed to the following experts who have so generously contributed of their time and expertise:

CHARLES E. HANSEN, M.B.A., is a consultant in information management, energy, economics, and market research and intelligence with RTM--Resource and Technology Management Corporation. He has directed major projects involving technology transfer and accelerated market penetration for energy and conservation technologies and is Editor of the quarterly publication, "Alternative Energy Data Summary for the United States."

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GAINES E. MILES received his B.S. and M.S. degrees in Agricultural Engineering from Mississippi State University. He obtained his Ph.D. from Purdue University in 1972. Since then he has been a member of the faculty at Clemson University with teaching and research responsibilities. His research interests include systems analysis and microcomputer-based control of agricultural machines.

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NEW TECHNOLOGY AND TRAINING NEEDS IN ANIMAL AGRICULTURE

by
Virgil W. Hays, Chairman
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Animal production is a diverse and changing field, thus the necessary education and training is also diverse and changing. Students planning careers in animal agriculture need practical experience in the general care and husbandry of animals, training in applied animal agriculture, training in other agriculture disciplines that support animals and training in the basic biological sciences involved in reproduction, growth and development of animals.

GENERAL TRAINING IN CARE AND HUSBANDRY

Young people reared on livestock farms usually gain valuable practical experience in care and management of animals as a normal part of their growth and development. They develop an understanding of animal needs and usually have a strong concern for their welfare. However, with the continued urbanization of our nation and the increased specialization of farm units each year, fewer and fewer young people have any practical experience in working with animals. Of those that are reared on livestock farms, many may gain experience with only one species of animal. The lack of practical experience in the simple techniques of handling and caring for animals is frequently a limiting factor in learning other technical skills important to livestock production and is a major criticism from employers of many 4-year college graduates who have had little opportunity to work with animals and possibly none outside a formal course setting.

There is an urgent need for the establishment of apprenticeship programs in modern production units that will provide the opportunity for students to gain the necessary husbandry experience. The apprenticeship programs need close supervision to assure that participants truly receive a broad training rather than being relegated to the same routine tasks throughout the training program. However, it is equally important that an understanding be developed that the routine chores are an essential part of livestock husbandry and that even short periods of neglect can be highly detrimental to production.

Student operated and managed livestock farms associated with vocational schools equipped to provide additional technical training and staffed to provide expert supervision of the farm would provide an excellent setting for gaining practical experience along with other technical training. Such a farm should be managed and operated as a commercial unit, and not as a research unit or a public exhibit.

This needed training is not so much a result of developing a changing technology as it is a result of the changing background of students entering animal agriculture. It is of critical importance, however, that the apprenticeship programs or the vocational school operated programs permit the students to be exposed to the latest in technological advances.

TECHNICAL TRAINING FOR RATHER SPECIFIC ASSIGNMENTS ON LIVESTOCK FARMS OR FOR AGENCIES SERVICING LIVESTOCK PRODUCERS

Animal agriculture is a science-based industry that utilizes the basic developments in chemistry, biochemistry and physiology. Artificial insemination (A.I.) has been practiced for many years, particularly in dairy cattle, and there is a continuing need for skilled A.I. technicians. Difficulties in detecting estrus have hampered maximum use of this important means of making rapid genetic progress. New technology is being applied or will be in the near future which will increase and expand on the application of A.I. and will increase the need for technicians to practice total reproduction control.

Estrus synchronization, artificial insemination and parturition control are technological developments that can have a great impact on animal production. This technology will permit livestock producers to exercise far more precision in controlling all stages of animal production including controlled breeding, through estrus synchronization, and timed parturition, which in turn will allow effective calendarization of the complete production cycle. This precise control of reproduction will facilitate more effective control of housing, feeding, disease prevention and management programs throughout the production and marketing cycle.

Technical training in the biological processes of estrus, ovulation and parturition and in the mechanisms by which drugs, chemicals and management procedures can be used to control these phenomena, and practical training to develop the necessary skills for administering the materials, detecting estrus and inseminating the animals are necessary for effective application of this technology.

TECHNICAL TRAINING IN APPLICATION OF COMPUTERS TO LIVESTOCK PRODUCTION

Success of a livestock production unit is dependent on skillful application of the technology that directly impacts on rate and biological efficiency of animal production; but, success is also highly dependent on efficient capital and resource management. Skillful application of technology and resource management are both dependent on an accurate and complete set of records. Records on animal performance, costs of production and returns for each stage of production are essential for decision making. Keeping accurate records in a form in which they can be effectively used is time consuming and frequently neglected but can be greatly facilitated by rapidly advancing computer technology. Computer technology is playing an increasing role also in monitoring and controlling environment in livestock buildings, in processing and distributing feed and in managing animal wastes. The training needs differ from the more generalized computer programmer or data processors in that there is a need for combined training in animal production and application of computers.

TRAINING IN DISCIPLINES THAT SUPPORT ANIMAL AGRICULTURE

As an example of rapidly changing technology in a discipline related to animal agriculture, we can look to agriculture engineering. Livestock units are highly capitalized with expensive buildings and equipment that are continually being improved. There is an increasing need for people trained in agriculture mechanics who also have sufficient training in animal sciences to appreciate animal needs.

Heating and ventilating farm buildings, processing and distributing feeds, and removing and disposing of wastes are often highly automated systems that require special skills in operating and maintaining the equipment. It is important for the workers to have training and experience with the electrical and mechanical systems of the equipment used. This training is important for the purpose of maintaining the functionality of the equipment, but it is also of extreme importance for the safety and general welfare of the workers and animals.

The overall success of a livestock production unit is not only dependent on the skillful application of the technology that directly impacts on the rate and biological efficiency of animal production, but it is also dependent on other related technologies such as engineering mechanics, crop production and preservation, resource management and economics, computer technology, etc. Some units will be sufficiently large to have a full-time engineering technician or other specialist, but more often the situation requires a combination of a good animal husbandman with special expertise in another area such as computer technology, mechanics, etc.

The high cost of maintaining adequate numbers of animals, altering equipment and housing to incorporate the latest developments, and labor to fill in between groups of students make it imperative to use a combination of classroom teaching and some type of apprenticeship programs. There is an increasing need for skilled workers in the field of livestock production.

AQUACULTURE

by
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Aquaculture may be defined as that component of agriculture in which aquatic plants and animals are farmed in fields covered with water. Aquacultural production from fresh, brackish and marine waters certainly can augment fish catch from the sea and inland waters. In fact, aquaculture presently accounts for more than ten percent of the total world fish harvest--estimated to increase to 20 percent by year 2000. Even now, aquaculture provides 40 to 50 percent of the total fish consumed in some countries, compared to eight percent for the United States.

The world catch of wild, non-cultured fish was approximately four million metric tons in 1900. With increased effort and improved technology, the total world harvest of aquatic plants and animals (excluding whales) from the oceans and freshwaters increased to ten million tons in 1930; to 20 million tons in 1950, and to 70 million tons in 1970. Since 1970, the total world fish harvest has fluctuated around 70 million tons annually. Fishery scientists generally agree that further increase of the world fish catch is doubtful given present technology, high energy costs, and the replacement characteristics of the fishery resource.

The United States imported over 50 percent of fish and shellfish products consumed in 1977, resulting in a $2 billion balance of trade deficit. Increased aquaculture production could help reduce the U.S.

trade deficit, and concurrently, help satisfy the U.S.'s (and World's) growing need for fish. The per capita consumption of fish in the U.S. increased from ten pounds in 1960 to 13 pounds in 1980. Over time, this trend of increased demand for fish and shellfish is likely to continue in view of superiority of fish flesh over red meats in terms of protein quality, with little fat and no carbohydrate.

AQUACULTURE IN THE U.S.

Aquaculture has been practiced in China and other Asian countries for many centuries; however, it is a relatively recent addition to the American farm commodity group. The aquaculture industry in the U.S. has grown rather dramatically during recent years, with a total aquaculture production of 94 thousand metric tons in 1980 valued at $200 million.

The major food products produced through aquaculture in the United States in 1980 included catfish, trout, oysters and crayfish, with catfish contributing the greatest value ($54 million) and greatest weight (35 thousand metric tons). The aquatic animals with greatest potential for future aquacultural development in the U.S. probably are catfish and crayfish. At present, approximately 3,800 farmers are operating about 80,000 acres of water for catfish, while 70,000 acres of water are managed for crayfish.

The catfish market is presently depressed due to overproduction through overexpansion during the past 2 years--increases of 25 and 41 percent in catfish farming area under operation in 1980 and 1981, respectively. However, with continued effort in market development in geographical areas where catfish is not a traditional food product, demand undoubtedly will increase substantially in the future.

Because of high capital outlay required for pond construction, it is quite likely that new fish farm construction will slow appreciably, and that production increases in the near future may occur more from application of improved management skills and practices rather than from new farm operations. Aquaculture technology has been developed by various institutional research groups and by innovative fish farmers. Technology has improved to the extent that an efficiently operated fish farm now routinely produces a total annual harvest of 4,000 to 5,000 pounds of catfish per acre (compared to 2,000 pounds per acre 20 years ago) at a net profit to management of around $500 per acre of water.

NEED FOR SKILLS TRAINING IN AQUACULTURE

Academic training in aquaculture at undergraduate and graduate levels is available at a number of public and private educational institutions in the United States. Graduates subsequently find employment primarily in state and federal agencies and in the university community. However, other than a variety of short courses, practical "hands on" types of training programs designed especially for aquaculture technicians or operators are extremely limited in the United States. With the relatively rapid growth of aquaculture and the continuing need for skilled, on-the-farm aquaculture technicians who are knowledgable in various key areas, including fish reproduction, pond fish production, fish nutrition and fish health, the establishment of a vocational or post-secondary aquacultural training program should be seriously considered.

Many Asian countries, where aquaculture consititutes an important industry, have developed fisheries and aquaculture training programs at high school and junior college levels. Trainees are given formal training in aquacultural principles and theory at the schools, while practical experience is gained by the trainee working on an operating fish farm.

In the U.S. context, and with the degree of technology presently practiced, it is important that such a training program be established at institutions which not only have technical staff experienced in various subject matter areas but appropriate field facilities where trainees could acquire on-the-farm practice. The training program should extend over the entire calendar year, or at least for one complete growing season (about 9 months). Each trainee should be assigned his own pond and be responsible for all management activities starting in the spring when the pond is filled with water and stocked with fish. Feeding fish, seining fish to determine growth and adjusting feeding rates and all other pond activities, including collection of water quality data, should be carried out by the trainee. Further, at the end of the growing cycle, each trainee should drain his pond, recover the fish and analyze the fish crop in terms of total production, size distribution and economic return.

Particular care should be taken to formulate a program that gives adequate theoretical background to ensure that the trainee understands why a specific procedure is followed. Also sufficient practice should be provided so that the trainee gains confidence in operating appropriate field and laboratory equipment including pH and oxygen meters, microscope, aeration devices, engineering transit or level and heavy equipment items such as farm tractor, back hoe and power driven fish feeder.

The trainee should master the techniques of induced spawning by injecting brood fish with hormone materials. Also, the trainee should develop skills in handling fish eggs to affect maximal survival to fry and fingerling stages. The trainee must develop skill in recognizing the state of health of pond cultured fish, e.g., when medicated feed should be given as compared to treating the entire pond area with a medicinal product. Skills must be acquired in transporting fish with minimal physical stress in live-haulers to processing plants or fish-out ponds.

In summary, there appears to be a need for practical training programs in the aquacultural industry at the post high school or pre-university level. Such a program should be of sufficient duration to permit the trainee to gain on-the-job experience over a complete growing season. Emphasis should be placed on "learning by doing", with adequate theory provided to enable the trainee to understand the whys and wherefores. The trainee also should be provided the opportunity to grow a crop of fish, being responsible for all management activities from stocking fingerlings to harvesting food fish.

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MICROPROPAGATION OF PLANTS WITH PREPLANNED GENETIC CHARACTERISTICS

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This topic refers to the use of tissue culture systems for mass propagation of selected plants by cloning or asexual reproduction. Mass production of new plants may arise from a single cell through miosis or division or from leaf stem or root cuttings, meristems, runners or stem tips. Systems of mass propagation may be economical and a unique means of propagating improved disease-free specimens. The most significant applications have been with the Boston fern, strawberries, potato, asparagus, African oil palm, pineapple and banana. The micro-propagation of plants through tissue culture, primarily of shoot tip explants and embryos, will be addressed because they have been found the most useful. Rapid clonal mass propagation is the objective.

The work duties would involve laboratory training of three to six months in the basic essentials of tissue culture, and in the application of elementary principles of biology, and organic, inorganic and hormone chemistry. The work duties initially involve the establishment of live and growing plant material in culture from explants, multiplication of propagule in culture, and establishment of rooted plants and hardening them off to survive into soil, and finally transplanting into soil in open fields with resultant rapid growth and development. Proper conditions must be worked out with each species and tissue type. Special culture flasks, or ordinary sample bottles and test tubes may be used. Many media formulations have been developed. A good place to start would be with the report of Murashige and Skoog (1962) and Murashige (1974 and 1977).

Tissue culture media are also ideal for the growth of a multitude of other competing living organisims. The importance of a sterile environment and equipment for minimizing contamination must be emphasized and be an essential part of the training program.

Work duties and required skills will change with time and as new technologies are developed. There will also be the opportunity to develop from one work activity and skill level to levels progressively higher and activities more delicate and refined. The simplest and most useful procedure is the culture of short tip explants. Work and skills can then progress to embryo culture, thence to anther or haploid culture, and eventually to protoplast or single cell culture and the reconstitution of whole plants, and finally to the fusion of vegetative cells of divergent species, with subsequent callus formation, organ differentiation and the building of new plant species. Each step in the above procedure will require added skills and knowledge of factors controlling plant growth.

Some special laboratory equipment and facilities will be required. These include a good hand lens, and a low and high powered microscope, an autoclave for sterilization of media and containers for culture bottles, and a containment facility or positive pressure sterile room facility for safe transfer of cultures, media and explants. An air-conditioned culture room with artificial lighting (fluorescent and incandescent) and temperature-controlled room (both heating and cooling) or a plant growth chamber are also essential. There should be ready availability of suitable plant material--Boston fern, potato, asparagus, African oil palm, pineapple or banana. Small greenhouse facilities with plant containers and sterilized potting media or soil are required for growth of explants to normal plants which can then be transferred to the open field.

Micropropagation of plants has been progressing rapidly with new economic applications almost daily. Clonal-propagation is currently the most important commercial use of plant tissue cultures. This is because of the increased speed by which improved plants can be produced. Many ferns, such as the Boston ferns and other indoor foliage plants, certain woody ornamentals, diverse bulbs and flower crops are now being produced in commercial laboratories. These laboratories are divisions of existing nurseries.

The commercialization of hybrid asparagus is just beginning. Hybrid asparagus production will be totally dependent on tissue culture required for the clonal propagation of explants from selected (male) parents to avoid inbred depression.

The culture of embryos, ovules, ovaries, cells and tissues, anther and microspores and protoplasts (single cells)--all are currently or potentially applicable to plant hybridization.

During the past three years a total of 171 biotechnology corporations, laboratories or genetic engineering establishments have had their origin in the United States. About ten percent have a major focus on agriculture for improved methods of propagation and acquisition of superior genetic material through genetic engineering. Much of the focus is on cellular and molecular biology. Micropropagation technologies will be essential for fulfillment of these efforts.

Tissue culture has already become economically significant. It will soon become common practice in agriculture, especially for rapid clonal multiplication and in establishing pathogen-free stocks. The storing and transporting of plant germ plasm will for many ornamentals, flowers, fruits, vegetables, forest trees and such crops as oil palm, potatoes, bananas, and sugar cane, soon become routine through in vitro cultures.

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SOIL-LESS PLANT PROPAGATION - NUTRIENT FILM TECHNIQUE

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Soil-less plant propagation refers to is to systems and techniques for producing high value crops or plants without using soil as a rooting substrate. This can be by hydroponics or soil-less culture, or by using a variety of substrates including peat, rock wool, or artificial mixtures of peat, sand, vermiculite, perlite, etc. The most advanced hydroponic or soil-less culture technology is the nutrient film technique which utilizes plastic flumes or gulleys through which flows a thin stream (one millimeter) of nutrient solution which continuously bathes the roots of the plants. The method may be used for crops grown in greenhouses or in the open. It is the essentials of this technology which will be treated herein-- the basic principles apply to all types of hydroponic or soil-less plant culture.

Work duties require training or background experience in plant growing, including crop response to plant nutrients, water, temperature and light. A basic knowledge of how plants grow and the essential requirements for growth is needed. Special attention should be given to high value and economically important crops, commonly subjected and adapted to hydroponics or soil-less culture. These could include tomatoes, cucumbers, lettuce, strawberries and a variety of flower and foliage crops. Most any crop can be grown hydroponically, but it is not economically rewarding to do so.

Work duties also include planting and germination of seed, transplanting and spacing of seedlings or young plants to properly prepared water, sand or gravel (aggregate) medium. Nutrient solutions especially formulated and maintained must be prepared. There are many formulae to choose from (see Wittwer and Honma, 1979) and (Jones, 1975). Plant care following transplanting and rooting includes providing physical support, pruning and training where necessary, and pollination in the case of tomatoes. Plant disease and insect problems must be addressed and control measures established. Records should be kept of costs, production, and returns. Crop removal and disposal of residues and cleaning the greenhouses or growing areas and renewal for subsequent crops is required.

Special skills are required in planting and germination of seeds, and for the techniques of transplanting and rooting of seedlings. A recognition of water requirements and the need for timely irrigation and nutrient feeding and a sensitivity to nutrient deficiencies and toxicities is essential. A basic knowledge of plant nutrition and nutrient requirements must be acquired with sufficient expertise to maintain adequate levels of plant nutrients in the solution. Some skill in the pruning and training of plants will be necessary for cucumbers and both the training and pruning of plants and pollination for tomatoes. The special technologies associated with growing plants with the nutrient film technique should be acquired by carefully following directions in the published reports (see Wittwer and Honma, 1979) or by personal observations and review of established units. Skills relating to pest control and specifically pest management are necessary and a pesticide applicator's license acquired according to state requirements or regulations. In conclusion, successful hydroponic culture of crops is high technology and requires a series of skills.

Special equipment and facilities must be acquired. This can range from the very simple where seeds of beans and grains are sprouted for home consumption to complex systems of growing of plants to maturity. For the latter, containers and a soil-less medium (artificial mixes, rocks, wool, etc.) are needed in which to plant the seed and into which the transplants are set and rooted. Plant growing structures consist of greenhouses, growing beds, plant supports, pumps, and heating, ventilating, and air conditioning systems of varying complexities (see Jones, 1975). A means of carbon dioxide enrichment within the greenhouse is highly recommended. An aggregate of gravel or other substrate is used in the more conventional systems and irrigation with the nutrient solution may be managed either by a drip system or pumps for periodic watering. For the nutrient film techniques, 18 inch wide black polyethylene film (four ml) is required which can be laid on smooth ground or on eight inch wide hard board. There should be a slope in the plant growing area of at least one inch in 100 feet. Other essentials for hydroponic culture are a source of good water and a support system for the aerial parts of the plant. This can be done with stakes and wire or twine. A storage facility protected from light for the nutrient solutions is essential.

The potential for hydroponic culture of high value crops has never been greater nor the constraints more critical. A growing interest in recent years in the technology has not abated even though the science of growing plants without soil has been known for over 100 years. There seems to be a continuing romance associated with the science and technology of hydroponics. Seldom are commercial installations an economic success. Capital investments, resource inputs, labor requirements and management and technology input remain high. The industry is currently characterized by widely dispersed small units throughout the United States which capitalize in part on the production of specialty products that command a premium price in local or community markets. There are no large scale units that are notable financial successes.

Interest in hydroponic culture will continue to be attractive. The skills are in demand for those few that have them. Crops widely cultured are tomatoes, cucumbers, lettuce and flowers, and this will continue. While large scale commercial soil culture of greenhouse grown vegetables will not likely extend through the 1980's, hydroponic culture will continue to be attractive and appealing to a selected group of people.

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"PERSONAL" COMPUTERS IN AGRICULTURE

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Microcomputers are being rapidly adopted as a tool in modern agriculture. Some observers are calling them "...the next revolution in agriculture." Microcomputers are small-sized (desktop-portable) general purpose computers with many of the logical capabilities of larger machines and supportive of various peripherals and high-level software. They have potential applications in all facets of agricultural production and related agricultural services.

Microcomputer applications in production agriculture cover a broad range of activities which include the following:

- record keeping (financial, animal, field, equipment, etc.)
- budgeting
- enterprise analysis
- day-to-day decision making
- payroll and check writing
- access to market news and weather information

In the area of agricultural supplies and services occupations, microcomputers can be used for the following:

- general ledger
- accounts payable
- accounts receivable
- payroll and check writing
- sales analysis

- job costing
- inventory management
- mailing lists
- word processing

Of the new knowledges and skills necessary to understand this technology, one of the first is an awareness of the terminology and jargon associated with microcomputers. In a sense, it will be necessary for the student to learn a new language. The more advanced student will need to be exposed to one or more of the higher level programming languages, such as BASIC, FORTRAN, COBOL, PASCAL, etc. It is particularly important that the agriculture student have a good appreciation for agricultural applications of microcomputers and how to effectively utilize microcomputers in agriculture. The following paragraphs address the latter in more detail.

In order to effectively utilize microcomputers in production agriculture and in agricultural sales and services occupations, the potential user must be extremely cautious in the selection of a microcomputer system. First they must be aware of the fact that a microcomputer system includes two major components, hardware and software. And before a system is selected, the potential user must identify the particular tasks to be performed with the microcomputer system. Once this decision is made, the system selection should focus first on software. Software refers to the programs that are used by the microcomputer to perform tasks and solve problems. Software also includes data that may be needed by those programs. Only after the appropriate software has been identified and judged to have the capability of performing the required tasks should the hardware search begin. Hardware refers to the equipment (microcomputer and its peripherals, i.e., printers, disk drives, etc.). The hardware selection process should investigate all brands of microcomputers available that will run the software identified in the software search. Agriculturalists who use microcomputers should expect that over the life of the hardware the software costs are likely to exceed the hardware costs.

There are several potential sources of software which might be used in agricultural applications. They are identified below with some of their associated advantages and disadvantages:

- Vendors of microcomputer hardware - usually have been thoroughly tested and have adequate documentation (users manual). However, they are general application programs and not specific to agriculture. They are more applicable to agricultural supplies and services occupations than to production agriculture.
- Commercial Agricultural Software Suppliers - designed specifically for agriculture, however they are usually more expensive than software marketed by hardware vendors. Testing, documentation, and support may not be adequate.
- Agricultural Extension Services - designed for agricultural applications and usually less expensive than commercially marketed software. Many have not been thoroughly tested and documentation may not be available.
- Custom Developed - specific to user situation, but can be very costly.
- "ser developed - specific to user but also can have a high cost, if not in direct cost, in time.

It is also important that the potential user of a microcomputer system know how to determine a systems capability in order to determine if it will run certain software. One of the capability measures is internal storage or Random Access Memory (RAM), commonly referred to as "K". One K is about 1000 characters of information, or about one typewritten page. Microcomputers are available with capacities from one K to over 500 K. Many of the microcomputers being used today in agriculture have a maximum of 48K or 64K. This is needed for much of the agricultural software now being used.

In addition to internal storage, many agricultural applications will need storage capacity outside the computer for programs and data. The most common external storage devices are cassette tapes and floppy disks. Cassette tapes are written onto and read by a standard audio cassette player while floppy disks require disk drives. Cassette storage systems are less expensive than floppy disk storage systems, but are more cumbersome and time-consuming to use. Floppy disk systems are recommended for agricultural applications and for convenience of use. For added storage capacity, two disk drives are desirable.

Putting information such as computer instructions, program statements and data into the microcomputer is accomplished using keyboards much like typewriters. These devices are standard with almost all microcomputers. Also standard with almost all microcomputers are video-display-units--television-like screens--for displaying information that is fed into the computer from the keyboard and results obtained from running a program. (Those microcomputers which are not marketed with a video-display-unit can be attached to the standard home television for video output). Output which is displayed on the screen is called soft copy output. Often there is a need for hard copy--printed--output. This is an optional item of hardware, but one that is highly recommended in agricultural applications. The most common printers will print from 80 to 132 characters per second. Printers are normally rated in terms of their speed of printing which is measured in characters per second (CPS). The most commonly used printers are in the range of 25 to 200 CPS. Printers are either dot matrix--standard computer quality--or letter quality--typewriter quality. Letter quality printers are slower than similar priced dot matrix printers. For many agricultural applications dot matrix printers are satisfactory and printers with speeds of 100 CPS or greater are commonly used. Agricultural users who make extensive use of word processing software will need a letter quality printer.

Cost of the hardware components in a microcomputer system used by agricultural producers and agricultural supply and service organizations could range from as low as $200 to over $10000. However, a typical system with the components recommended above will usually cost in the $3000-$4000 range. This would include a microcomputer with 48-64K RAM, two disk drives, and a dot matrix printer rated at 100 CPS or greater or a letter quality printer. Again, it should be emphasized that this is the hardware cost only and that the software cost will probably exceed hardware cost over the life of the hardware.

In order to teach the knowledge and skills necessary to the understanding of computer applications in production agriculture and agricultural supply and service occupations, special equipment and uniquely trained personnel will be needed. Equipment needs are in the form of microcomputer hardware of the type described above. A microcomputer with at least 32K RAM and one disk drive will be needed for every two students so that every student will have ample opportunity for hands-on experience. A printer for every eight to twelve students will probably be adequate. One instructor can manage a laboratory section with 12-16 students, with a teaching assistant being highly desirable and necessary for a section with more than 16 students. The maximum number of students in a computer lab section probably should not exceed 24. Instructors of courses on computer applications in agriculture should have computer knowledge and skills and a good understanding of technologies associated with modern agriculture.

Microcomputer technology is extremely dynamic. The internal capacity of microcomputers has increased eight times since they first appeared in the late 1970's. The early microcomputers were built around eight-bit microprocessors which limited their capacity to approximately 64K RAM. A 16-bit microprocessor has been available for more than a year and microcomputers which utilize these processors are just becoming available. These 16-bit microcomputers have up to 512K RAM. Speed of computation of the 16-bit microcomputers vs. the eight-bit microcomputers also increases substantially. It is possible that 32-bit microprocessors will be used in microcomputers in the next three to five years, further increasing storage and computational speeds. Even if this does not occur, there will be tremendous advances in the impact of microcomputers on agriculture from the point of view of software. There will be more and better agricultural software developed in the next three to five years for both the eight and 16-bit microcomputers. It will be easier to use and have better documentation. There will be a need for educators to keep track of these developments so that they can use and recommend for student use the better software. Microcomputers on the farm and in agribusiness will be commonplace in five years. It is not inconceivable that half of all farmers, except those with small farms, will have a microcomputer by 1988.

MICROELECTRONIC MONITORS AND CONTROLS IN AGRICULTURE

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Monitors and controls which reduce the cost of production are commonplace in agriculture, but potential applications of microelectronics are much greater. Microelectronics include microprocessors and other Large-Scale-Integrated (LSI) circuit chips containing thousands of transistors or logic elements. Microprocessor-based monitors and controls are highly versatile because they can be readily adapted for new situations through programming. Figure 1 illustrates the typical components of a microelectronic monitor and similarly Figure 2 depicts a microelectronic controller. The primary difference is the addition of an amplifier and servo or actuator in the controller. The computer program checks the status (high or low) of sense line(s) connected to some binary transducer(s) and/or the voltage level of some analog transducer(s) (via the analog to digital converter) and often displays the results or sets an an alarm. The servo or actuator is turned on whenever the conditions prescribed in the program are met. The control algorithm may be simple or extremely complex requiring many input lines.

Examples of monitors and controllers are numerous. Most grain combines now have monitors which sound an alarm when selected shaft speeds fall below certain settings. Grain-loss monitors are used to warn operators of excessive losses. Planter monitors count the seed planted per row. Hand-held moisture meters are popular sensors for monitoring the moisture content of crops during harvesting operations. Monitors for displaying tractor performance (speed, slip, draft, and

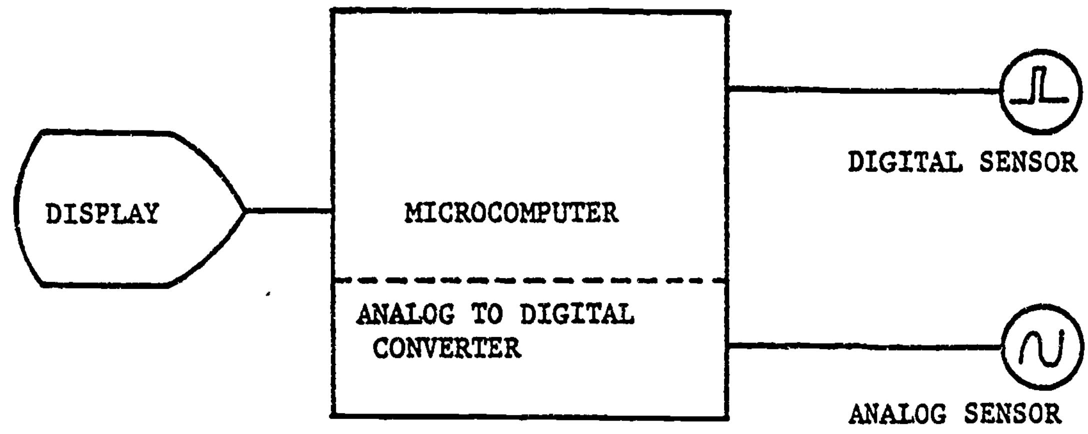

Figure 1. Microelectronic Monitor

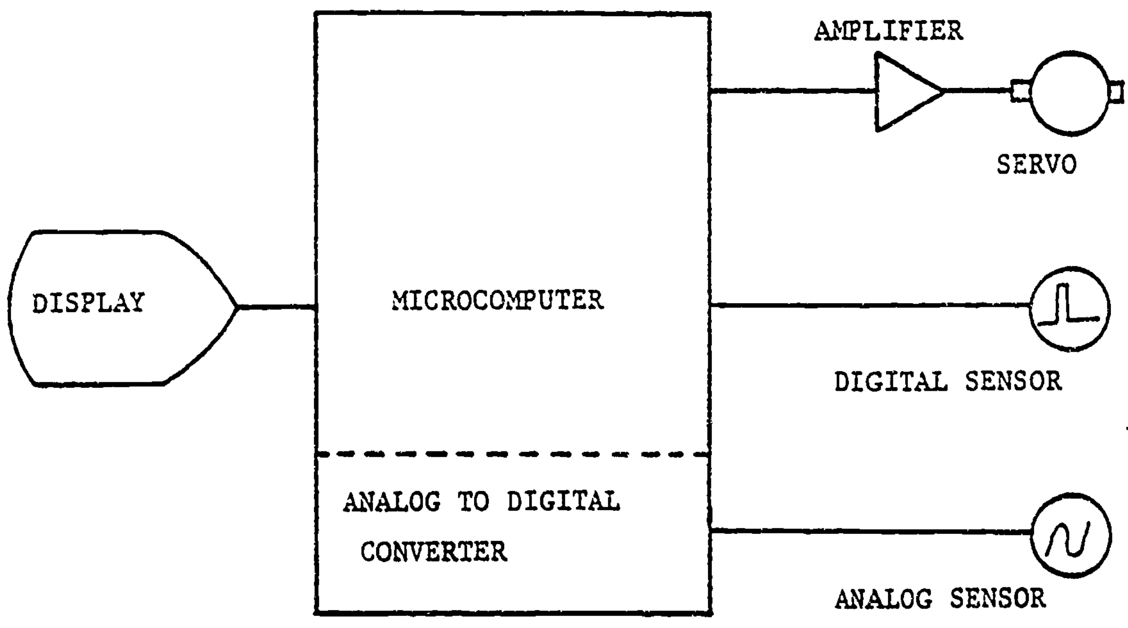

Figure 2. Microelectronic Controller

fuel consumption) are also available. Sophisticated, microprocessor-based controllers adjust spray volume based on actual vehicle ground speed. Other controllers automatically change the reel speed as combine ground speed varies. The number and complexity of future microelectronic monitors and controllers are sure to increase dramatically.

NEW ACTIVITIES OR DUTIES REQUIRED OF THE USERS

Fortunately, not a great deal of new knowledge or activities are required of the users of these innovations because the complicated circuitry is transparent. However, in most cases the user must possess an appreciation for electronics. Using many of these devices will be like using a calculator. One must know how to perform simple arithmetic, but using one doesn't require a knowledge of microelectronics, even though care must be taken to insure that the correct answers are obtained.

Future controllers and perhaps monitors will be highly sophisticated and some will require programming by the user. Key pads, thumbwheel switches and other similar devices will enable the user to program the device to perform the desired functions. Knowledge of a high-level programming language such as BASIC or FORTRAN is not required but an integral knowledge of the process being controlled or monitored is essential.

KNOWLEDGES AND SKILLS DEMANDED BY MICROELECTRONICS

The manufacture, sales, service and, to some extent, use of microelectronics require unique skills. Employment opportunities will exist in companies manufacturing microelectronics for agriculture.

Printed circuit board soldering, insertion of chips, circuit graphing of layouts, etching of circuits, and other board-level skills will be required by the manufacturer. Persons working in manufacturing must also be able to use oscilloscopes, digital multimeters, function generators, logic analyzers and other sophisticated testing equipment.

The sale of these products does not require the detailed, board-level skills required in manufacturing. However, the highly competitive nature of agribusiness favors the salesperson who is able to intelligently discern between good and poor products and who recognizes the practical limits (or range of applicability) of the microelectronic devices. Thus a working knowledge of microelectronic terminology and perhaps the ability to read circuit diagrams are highly desirable.

Servicing, repair and perhaps installation of these products will occur in the field and in a dealer's service area. Field service will generally be a component swap. Thus the skills needed are the ability to read and comprehend block diagrams and circuit diagrams. Removal and insertion of chips and/or boards will be a common practice. Some dealers will establish service areas capable of board-level repair and/or modification. Such employment opportunities require skills similar to those required for manufacturing.

The user familiar with calculators, videogames, and personal computers should have little trouble programming (adjusting) his controller or monitor. The person not exposed to personal electronics may have trouble comprehending and responding to even the simplest of displays or alarms.

SPECIAL EQUIPMENT OR FACILITIES REQUIRED FOR TEACHING MICROELECTRONICS

Teaching the use of microelectronic monitors and controllers often will be done by the sales/service force at local dealers. Because each product is so specialized, its use will have to be explained on a one-on-one basis. Special sales demonstrations will also provide explanation of how to use these devices.

Teaching the manufacturing, sales and service skills requires a considerable amount of highly technical equipment and laboratory space. hands-on experience during the learning process is essential for good education. A well-equipped center should contain soldering irons, oscilloscopes, digital multimeters, power supplies, logic analyzers, and photographic equipment for developing prints and etching circuits onto printed circuit boards. Perhaps some centers should contain equipment to program microprocessors such as development systems and EPROM burners and erasers. Centers for teaching the board-level skills are required near manufacturing areas of the country.

GROWTH TRENDS IN MICROELECTRONICS

Microelectronics and microprocessors in agriculture promise to be one of the most rapid growth segments of the American economy. The farmer's demand for tools to enable him to produce at a profit means more sophisticated monitors and controllers (i.e., microelectronics) are needed to reduce costs because prices are virtually fixed by cheap-food politics. University and industry researchers are developing new, highly-sophisticated controllers for many new applications. One controller would optimize tractor performance and minimize the fuel required to perform tillage operations. Another would use past, present and forecast weather conditions to simulate grain drying and simultaneously minimize the amount of external energy required to dry a crop. Combine adjustments will be made automatically, thereby reducing harvest losses and increasing the quality of the grain. Precise placement of pesticides and fertilizers will be made possible by highly sophisticated controllers which monitor environmental conditions, soil type and location within a field.

The process of making American agriculture competitive worldwide through the wise and profitable use of highly-technical, complex microelectronic monitors and controllers has just begun. The future will no doubt make many innovative products available to farmers.

NEW TECHNOLOGY IN AGRICULTURAL MACHINERY AND EQUIPMENT

by
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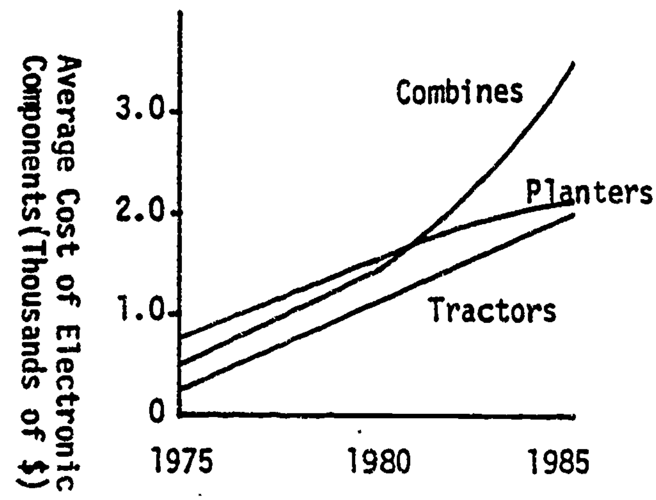
Agriculture is now nearing the end of an era of dramatic crop yield increases brought about through advances in plant breeding and fertilization. The promise of new production breakthroughs has yet to be realized, so attention has turned to improving the efficiency of the production process. Developments in farm machinery are following that same pattern.

The rapid advancements in horsepower and operator convenience made in the last decade have largely run their course. In this place are emerging more subtle, but none the less significant, developments to permit farmers to respond to their business environment. These developments include: more sophisticated operator inputs; improved energy efficiency; increased product reliability and enhanced productivity.

The principal carrier of these new developments will be electronics, the largest of the new technologies about to descend on the farm machinery industry. The electronics market for farm equipment is about to explode from its $6 million dollar value in 1980 to over $200 million in 1985 and to $500 million by 1990. The cost of the electronic componentry on a typical machine, now about one percent of the value, will jump to nearly ten percent of the total cost by the end of the decade (as shown below).

The rapid expansion of electronics already has major farm equipment manufacturers on a furious search for electrical engineers who know



something about farming. In turn, a solid knowledge of electrical technology will become a must for the farmers who operate these new "smart machines", as well as technicians who will maintain and repair them. Though most of the componentry will be designed as a subsystem for easy replacement, the ability to diagnose possibly complex electrical problems will be an asset in reducing equipment downtime. What's more, the grueling environment where electrical sensors and controls will be asked to work will make diagnosis and service even more important on agricultural equipment than it currently is in the aviation and automotive industries where the components are already widely applied.

Tractors, combines and planters will draw most of the attention of electrical designers. Combines, for example, will be loaded with sensors to monitor their every function, then relays to carry this information to microprocessors which will control combine operation. Hydraulic linkage will then permit adjustments in speed, guidance, cutting height and operating settings. As a result, harvesting losses will be cut from the current eight percent to below one percent. Similar developments can be expected on tractors to automatically adjust engine and drive train settings for optimum loading.

Computer technology will go hand in hand with electronics on tomorrow's farm machines. Microprocessor technology will tie monitoring equipment to an on-board computer system which will make control decisions. Instead of responding to individual functions with an operating adjustment, as occurs now, equipment operators will be called on to supply more sophisticated inputs, such as maximum and minimum control points that depend on individual crop, soil or weather conditions. Making these decisions will require a more technical understanding of basic engineering as well as plant and soil sciences. Also, a sound working knowledge in computer and microprocessor technology will aid both operators and service personnel. Computers are also likely to play a role in future diagnostic and servicing operations, permitting dealers and operators to detect and monitor developing engine, transmission and hydraulic problems prior to equipment failure, thereby actually scheduling downtime.

A more technical computer knowledge will be important in the engineering field as computers will play a larger role in the actual design and testing of new equipment. Computerized systems currently yield about ten percent of equipment designs, but are expected to perform almost all design functions before the end of this decade. Computer modeling, to test new designs and components under simulated operating conditions, will also be a rapidly expanding area among equipment manufacturers.

Energy uncertainty will be the seed for yet other developments in farm machinery. The diesel engine, though likely to remain as the primary power source, will undergo subtle but steady design changes to improve fuel efficiency. Increased use of turbocharging, which utilizes the power lost through the engine exhaust, will be one example. Engine operating temperatures will also increse significantly, potentially improving energy efficiency as much as 25 percent. Changes will also permit the use of lower quality, less specific, fuels. Meanwhile, research and testing of alternative fuels including vegetable oils, alcohol and synthetic products, will continue.

Though the changes in the diesel engine are sure to change its efficiencies, they will not alter the basic operating characteristics. Therefore, they will also not change the need for equipment operators and service technicians alike to develop a thorough knowledge of diesel engine mechanics.

All these changes will team up to craft machinery embodied with the most advanced technology available to deliver the highest productivity possible. Their operation and maintenance will demand the highest in both mechanical and management skills.

CHANGING TECHNOLOGY-PLANTING METHODS AND EQUIPMENT

by
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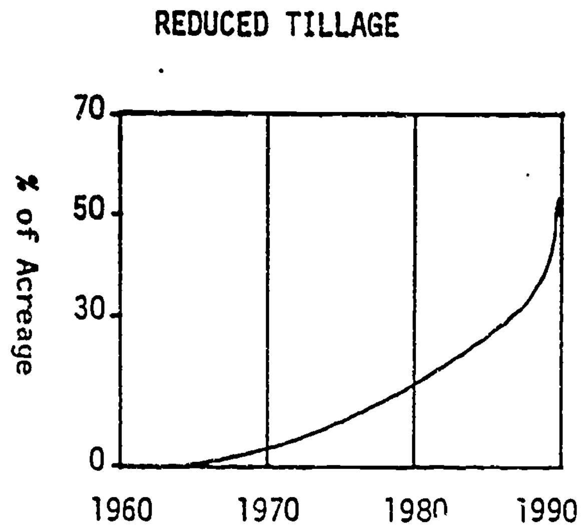
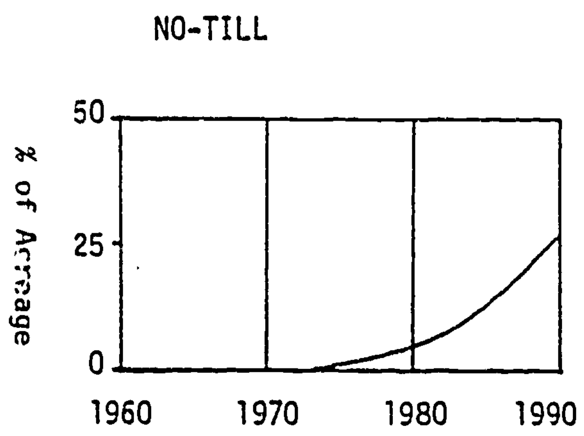
Because planting is such a critical function in the total farming operation, more engineering work has been directed at planting equipment. Consequently, planters are leading the farm equipment industry's plunge into the electronic era of sophisticated monitoring and control. In coming years, revolutions in seed metering and depth control will continue to improve planting accuracy in a wider variety of crop and soil conditions. Ultimately, planting equipment will include such features as infinitely variable seeding, fertilizing and pesticide application rates to match the soil productive capability of individual areas of the field. These application rates will be determined from computer stored information gathered as the previous crop was harvested.

This blending of electronics and computers will require equipment operators and service personnel to have a solid understanding of both technologies, and engineering personnel to thoroughly master their complexities. Manufacturers will assist owners and operators in these new technologies with stronger emphasis on training programs after equipment is delivered to the farm.

The rapidly growing trends of conservation tillage in the form of reduced tillage and no-till pose the most significant challenge to planting equipment in the future. Farmers will follow the trend to reduce or eliminate tillage operations to fight soaring production costs and reduce the ravages of soil erosion. USDA projections of the use of no-till, in which seed is planted directly into old crop residue, and reduced tillage, in which tillage operations are kept to a minimum, are shown in the two graphs below. A four-fold increase in no-till and a three-fold increase in reduced tillage are expected by the year 1990.





Planters and drills will be forced to adapt even more than present models to handle the heavy amounts of surface residue and soil surface irregularity commonly experienced with these tillage systems.

Since these tillage systems are different than conventional methods, operators will have to develop special management techniques to make them successful as well. Maintaining soil fertility and weed and insect control become more difficult, particularly in light of the growing environmental concerns over air and water quality. To cope with these challenges, technical training in plant and soil science will be required, as well as a thorough understanding of the social, political and environmental implications of crop production techniques.

Planting equipment will also reflect a gradual change of focus toward total production per acre, rather than total productivity per worker, as in the past. In terms of equipment design, this will result in tools better suited to multiple-cropping or inter-cropping, planting a crop immediately after or even directly into another.

Besides the ability to handle more trash and shoulder added sophistication, future planting equipment will also feature improved flexibility to plant a variety of row configurations. A boom in ultra-narrow row soybean production is already becoming evident, and will eventually lead to multipurpose equipment able to plant in an equidistant pattern with each seed allotted the optimum area for root growth and plant development.

Improved varieties and more precise chemical weed control will boost crop performance under these intensive cropping patterns. A versatile planter able to quickly alter seed spacing both in the row and between rows would permit these varieties to excel while cutting the investment farmers currently have in two or even three different types of seeding equipment.

CONSERVATION OR REDUCED TILLAGE

by
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Conservation tillage is emerging as a technology widely applicable to many crops and soil types. The residue of the previous crop is left as a surface mulch through which the new crop is seeded and weed control is effected by appropriately applied chemical herbicides. It is the most effective soil management practice yet devised as an erosion preventative and is becoming increasingly important for the conservation of soil, water, soil organic matter, and in the use of fossil energy. Reduced soil compaction from the use of less heavy equipment is an added benefit. Tillage operations are reduced to the minumum necessary to secure good seed germination and an adequate crop stand. The technologies of conservation tillage will be addressed.

Work activities differ from those for conventionally tilled (plowed) land for cultivated crop production. Since the land is not plowed, work duties must be focused on methods of drilling or planting seed, sometimes very small seed, through a trashy soil surface covered with residues of previously grown crops. Special procedures with appropriate equipment must also be adapted for drilling of fertilizer through the same trashy barrier. Both pre- and post-emergence chemical weed control is also essential. Since special seed and fertilizer drilling techniques and chemical weed controls are absolutely essential for a successful venture, specialized training and "hands-on" experience with the appropriate equipment must be provided. Familiarity with basic crop production practices is essential. Some training in basic soil properties and types is also highly recommended. This is especially important for soybeans, corn, wheat, sugar beets, field beans and vegetables such as tomatoes, cucumbers, and asparagus on which conservation tillage is now used extensively. Unusual disease and insect control measures may be necessary since the biota (living things) in and on the surface residues may reach much higher populations than on bare soil surfaces. On the other hand, some root diseases may be decreased because of less soil compaction. Special skills are required for securing good crop stands and acceptable pest control. A pesticide applicator's license will be required in some states.

Soils that are conservation tilled remain cooler and wetter for spring planting than those that are plowed. Hence, timing of planting or seeding operations is more critical. Soil compaction may be decreased in some instances and increased in others. It is important that crop yields not be sacrificed as conservation tillage is adopted. Mulches of some crops (grain sorghum, rye) have inherent allelopathic properties and provide a degree of weed cntrol without herbicides. Those engaged in conservation tillage practices should stay abreast of the latest developments in allelopathy. Chemigation, or the aplication of chemicals--pesticides, fertilizers, growth regulators--through irrigation equipment is a recent innovation highly compatible with conservation tillage. If used this will require special skills for metering the materials into an irrigation system.

Small experimental field plots with a total land area of five to ten acres, on which the principles and practices of conservation tillage can be demonstrated, will be required. Access to farms on which conservation tillage is being successfully practiced would be essential as a part of field trips in the training program. Seed and fertilizer drilling equipment that will penetrate soil surface plant residues must be acquired (rented or purchased). Appropriate spray equipment and herbicides for herbicide application in weed control is essential. Since the soil is not tilled or plowed it will be necessary to apply chemical herbicides. Those receivig training in conservation tillage should keep abreast of new equipment developments and the latest available from implement companies. An awareness of newly registered herbicides and comparative costs, resource inputs, yields, and economic returns derived from comparing conventional and conservation tillage is still in the developmental stages, even though widespread commercial adaption has already occurred.

The predecessors of conservation tillage, a series of technologies of the 1970's, were "minimum tillage," "plow-plant," and wheel track planting having their origins in the 1940's and early 1950's.

Conservation tillage now stands as an important land resource conservation technology. It is an alternative to the plow which has resulted in losses of billions of tons of topsoil from wind and water erosion. It can be observed in western Europe, the USSR, China, South America, Australia and Southeast Asia. Million of acres of sloping land in hilly areas which were formerly not suitable for agricultural purposes can now be brought into production or planted, or this acreage can be converted to more profitable crops. Conservation tillage may also increase efficiency in the use of fertilizers and pesticides.

It is estimated that conservation tillage will cover over 35 million hectares of crop land in the United States in 1982. This is up from 12 million in 1972 and scarcely more than one million in 1963. Expansion now is at the rate of 1.5 million hectares a year. It is projected that 62 million hectares or near half the total U.S cropland will be under conservation tillage systems by the year 2000. Crops most widely adapted for conservation tillage in the United States include corn, sorghum, soybeans and wheat. Other crops such as sugar beets and field beans and a variety of vegetables are now grown under the system.

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DRIP OR TRICKLE IRRIGATION

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The technology relates to the localized application of water and water soluble solutions slowly and uniformly to a crop at soil level or below and adjacent to the plant. This is done by mechanical water outlets called emitters, which are located at selected points along what are usually plastic water-delivery lines. Emitters may be placed on the surface of the soil or buried under the soil for protection and to reduce evaporation losses and the growth of weeds. The principle is to irrigate the crop, not the soil, and offers a means of greatly increasing water use efficiency and for direct placement of growth factors and plant protectants directly in the root zone. Drip irrigation is the frequent, slow application of water to soil through mechanical devices called emitters that are located at selected points along water-delivery lines. The essentials of this set of technologies will be treated.

Drip irrigation is an entirely different means than conventional systems in applying water to plants. The intent should be to keep soil moisture at optimum levels for plant growth. Participants in a training program must have some hands-on experience with the operation, installation and maintenence of established systems. Previous experience with providing the needs of plants for water by more conventional systems would be helpful. Work activities must include the planting and layout of the crop or crops to be irrigated. The cropping system is usually intensive (high plant populations per unit land area). Some advance familiarity with the various systems available would be desirable.

Field trips to areas using drip systems or attendance at one of the annual international agricultural plastic conferences and careful review of the published proceedings is recommended. A background of some basic knowledge of plant nutrition and pest control is desirable, and a recognition of plant nutrient deficiencies and toxicities and the ability either by measurement or observation to detect when plants are water stressed.

Special skills will be required in keeping the drip lines, water outlets and emitters from clogging, otherwise some plants will receive too much and others too little water. Water filters will have to be installed. An appropriate pressure of five to fifteen pounds per square inch should be maintained in the system.

One of the merits of drip irrigation systems is their adaptability for uniformly and efficiently adding nutrients (soluble fertilizers) and pesticides to crops. Special skills relating to the amounts and methods of metering these materials into the system are required. Drip irrigation systems are finding their greatest use in arid land agriculture with high value crops. Salinity often becomes a problem because of excess drying between waterings. This has to be avoided. Drip lines are not always laid on soil surfaces. The greatest efficiency in water use comes from subsurface installations.

Operators should become familiar with the techniques required for setting up such systems and if possible, in computer programming of water applications. One of the great advantages of drip irrigation systems is the saving of human labor (See: "The Blue Revolution," Natural History 1979).

The basic components for drip irrigation systems should be made available in any training program. These include a network of plastic pipes of graduated sizes which can serve as main lines and lateral lines. In addition, various kinds of emitters or discharge units (fixed, pressure regulated, adjustable discharge, micro-tubes) would be desirable. Other essential components are headers, meters, filters, screens, injectors, pressure regulators, pumps and clocks. Products meeting these several needs are available from many commercial companies. Because drip rates and pressures are low, main and lateral line sizes can be smaller than those required for sprinkler or surface irrigation.

Drip/trickle irrigation systems are gaining rapidly in popularity throughout the United States and the world. While drip systems are not new and date back as long as 50 years, it was not until the 1950's that they became established in greenhouses in western and northern Europe. Their first widespread field use was in Israel in the late 1960's. The new technology was first introduced into southern California for staked tomatoes and avocadoes and for young cherry orchards in Michigan in 1970. Worldwide, there were about 5,000 acres under drip irrigation in 1970. That grew to 72,000 acres in the United States in 1974, half of which were in California, and to 140,000 acres globally. The estimated figure for 1982 is over 1.2 million acres globally with well over 700,000 acres in the United States. A programmed effort is in progress in Hawaii to convert all of the approximately 100,000 acres of irrigated sugar cane to drip systems of which about 75,000 acres are now completed.

Drip irrigation systems have many attractions and advantages. They guarantee, with proper management, maximum water use efficiency. There is a remarkable reduction in labor costs over conventional systems. The entire capital investments for sugar cane plantations in Hawaii are returned within the first year of operation. In desert areas, drip irrigation can use water of higher salinity than would be acceptable with other irrigation methods.

There is a bright future for the new technology. The advantages of drip irrigation far outweigh any disadvantages for high value crops. As the demand for and the cost of food production and water grows greater, this remarkable technology for increased water use efficiency will expand. Water supplies for agriculture are limited and costly in most parts of the world. There are significantly increased yields with no loss in crop quality and less water is used. Labor costs are remarkably reduced and the efficiency of fertilizer applications through the system are greatly increased. The system can be completely automated resulting in uniform and efficient water distribution. The meteoric rise in the use of drip irrigation we have witnessed during the past decade is expected to continue.

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RENEWABLE ENERGY TECHNOLOGIES-AGRICULTURAL

by

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The effects of advancing renewable energy technlogies on agricultural work may be greater than their effect on all the other major consuming sectors combined--residential/consumer, commercial, and industrial. (For the purposes of this paper, RETs are limited to technologies concerning biomass, solar, and wind as sources of energy). Agriculture already makes extensive use of the principles underlying technologies under discussion here--biomass, solar, and wind as sources of energy--in their current states of development. These decentralized energy systems will find many more applications in agriculture in the near future.

The following agricultural work activities may involve exposure to the installation, operation, and/or servicing of these renewable energy technologies.

1. Farm management in general;
2. Agricultural mechanics/machinery; and
3. Specialized biomass-energy production.

In addition, we have grouped together the following relatively independent and specialized fields for consideration:

4. Horticulture, greenhouse operations and management, and forestry.

In all of these activities RETs are becoming more common as components of traditional agricultural energy systems and the crop production cycle. Knowledge, skills, and special equipment are addressed from the perspective of each of these work activity divisions.

FARM MANAGEMENT

The growing costs of conventional energy require not only increased energy consciousness in all operations, but an adequate understanding of when and where alternative/renewable energy systems may be used to advantage. For example, in heavy corn production areas or in operations where crop or animal wastes are generated in quantity, the potential of alcohol production or other waste conversion may be investigated. A farm manager should be briefly introduced to such concepts as:

- Agricultural Waste Utilization
- Crop Fermentation/Distillation
- Anaerobic Digestors
- Solar Collector Systems
- Wind Systems
- Total Energy Systems
- Energy Crops Potential

Special equipment is not considered necessary; however, a tour of some energy-conscious commercial farming operations where RETs are used in economically profitable ways would be most valuable.

AGRICULTURAL MECHANICS/MACHINERY

A study of general energy systems should include orientation in biomass, solar, and wind systems; training should include basic introductions to the types of machinery likely to be encountered with these systems including certain hazards and necessary cautions.

Biomass

An agricultural mechanic should understand the mechanics and the equipment of the new generation of wood stoves; they are much more sophisticated and efficient and must be more carefully sized to application. He may also be introduced to power alcohol production equipment depending on the feasibility of use considering crop availibility or animal wastes.

Solar

A mechanic should understand how a solar system in general operates, including an exposure to the complexities of the control and storage peculiarities of solar, and details concerning interface with conventional energy systems. It should be noted that solar heating can produce very high temperatures and pressures in some applications. In general, the equipment is more complex than conventional heating equipment, with numerous controls, valves, sensors, and piping components. No special equipment is considered necessary, but a detailed site visit to an operating active solar system would be valuable.

Wind/Water

Training should include the primary consideration of interfacing with commercial power systems and an introduction to wind-stress and tower/guy-wire considerations. Moreover, the possibility of utilizing this same wind equipment in direct pumping systems should not be overlooked. At this point, it might be noted that while major hydroelectric facilities and capabilities are excluded from this paper, the introduction of smaller water power applications might be quite appropriate in some regions.

Specialized Energy Crop Production

Although not currently in commercial practice, energy crop production is expected to appear in the late 1980's in some regions. An awareness of the possibility of growing crops specifically intended to serve as biomass/energy sources should be included in training. Major existing sources of commercially utilized material such as forests, as well as supplementary sources such as crop residue and a variety of waste materials are produced in agricultural operations. Crops or portions of crops that have traditionally been wasted may have substantial value as energy fuels. No special equipment is considered necessary.

HORTICULTURE, GREENHOUSE OPERATIONS AND MANAGEMENT, AND FORESTRY

Planning and design of horticulture projects might well incorporate RETs from the outset. Thus, clippings or other biological wastes might be predestined for biomass conversion, and the wind might be given a role in irrigation. Greenhouse operations might likewise benefit from biomass conversion of waste into fuels, with the wind given an added possible role--the generation of electricity. Of course, the ability of the greenhouse to perform as it does in hostile environments must serve as a constant reminder of the tremendous additional power of the sun that now lies just barely outside our grasp. And new challenges in the field of forestry will derive from wood's utility as a direct fuel in new generation wood stoves and as a source of biomass for conversion into fuels. These pressures will place greater priority on the need for forestry management to protect the position of forests as a watershed, and will include work in fertilization, genetic research, and appropropriate harvesting techniques. It should be recognized, for example, that wood can and will be a profitable crop in certain situations.

THE NEAR TERM FUTURE FOR RENEWABLE ENERGY TECHNOLOGIES

In the agricultural sector, renewable energy technologies will continue to grow. Their economy, more efficient use of resources and decentralized applications make biomass, solar and wind ideal for the farm environment. These technologies are expected to almost double by 1985;[1] about ten per cent of all U.S. farms will have some active renewable energy system in generation by that year. Although the majority of these systems will be wind, solar and biomass conversion are on their way because of their economic and waste utliization prospects. Technical training for agricultural occupations is one of the greatest avenues to encourage wise use of our resources in the near term by means of the new renewable energy technologies.

[1]Renewable energy technologies/sources are projected to reach 22 trillion BTU/year by 1985 as opposed to 12.7 trillion BTU in 1980 according to the "Alternative Energy Data Summary for the U.S.," RTM Corporation, March 1982.

INTEGRATED PEST MANAGEMENT IN THE VOCATIONAL EDUCATION SETTING

by

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Integrated Pest Management (IPM) is a unified, multi-tactic, conservation-oriented approach to the suppression of plant and animal pests, involving chemical, biological, cultural and physical techniques working together in economically-sound combinations. The on-the-farm objective for IPM is the reduction of pest organisms (insects, disease pathogens, weeds, nematodes and vertebrates--birds and rodents) to tolerable levels rather than total eradication, which is usually an impossible objective. Since a multitude of pest and beneficial species from a wide range of the biological world are involved in most agricultural systems, it is necessary to deal with the whole system in striving for maintenance of populations below economic or damage thresholds, lest one species may be satisfactorily reduced at another's expense; for example, chemical fungicides may adequately suppress a specific foliar fungus disease on a plant but at the same time reduce the population of beneficial fungi which help control insect pests. Thus, success in one sense produces a pest outbreak in another and the farmer must contend with both in her/his field.

IPM, then, is a holistic approach that lines up favorably with the way the farm operates. It contrasts with the single tactic approach that relied extensively on chemical pesticides and treated pests as though whatever was applied to one had no negative effect on another in the same system. IPM also relies extensively on chemical pesticides but it brings them into orchestrated play with other natural and applied forms of control or suppression. It also often reduces the number and cost of chemical treatments and, thereby, lengthens the effective life of a specific chemical pesticide, as the threat of pest resistance to it is reduced when pests are pressured less often. The increased benefits to the environment are obvious and crops are often of higher quality because of the proper timing of applications through the technology of IPM.

How does one implement the IPM approach on a farm or in a farming community? An IPM system usually involves several components, the most important being:

- Biological Monitoring
- Environmental Monitoring
- Pest-Crop/Animal--Nautural Enemy Models of Action and Interactions
- Rapid Communication System

Each of these components is integral to most IPM programs, with each relied upon to varying degrees in specific programs.

Biological Monitoring refers to surveying for pests on the farm or in the community to determine which pest species are present and in what distributions and densities. Beneficial species as well as crop development and condition are also monitored.

Environmental Monitoring refers to day-to-day tracking of weather, particularly the heat units that accumulate over a biological base/threshold, so that specialists can relate real-time weather to crop, pest and beneficial organism development. Knowing what weather has occurred up until a specific day enables the IPM specialist to judge what impact detected pest or beneficial organism populations will have on the crop, since weather somewhat differentially drives the development of these various organisms.

Models of Pest-Crop/Animal-Natural Enemy Actions and Interactions are usually developed by researchers and extension specialists and usually are computer-based. They logically relate what is known about various species in the cropping system, how they are affected by weather, crop characteristics, other organisms in the system, cultural practices, and many other factors. An IPM practitioner uses simplified models, often called management models, into which his/her biological and environmental monitoring information is fed to gain further insight and management options for implementation on the farm.

A modern Communications System is vital to making an IPM program function. Turnaround time must be short as a few hours in the case of many plant diseases if the information gained is to be usable on the farm to suppress the pest. Computers in a distributed network system are being extensively used for this purpose nationally, and many growers are already using microcomputers for this purpose. This field will explode with activity in the very near future.

IPM now represents a technologic field that involves a wide spectrum of skills at many educational levels, from vocational to Ph.D., from monitoring for pests to basic research, and from consultant to philosopher. Nurseries, greenhouses, agricultural supply stores, grain elevators and service cooperatives are turning at a steadily increasing rate to personnel with knowledge of and skill in the IPM approach. This will escalate as growers and other potential users of IPM increase their awareness and desire to utilize the approach. Throughout the U.S. an extensive need exists for well-trained Biological Monitors, often referred to as "scouts," "pest scouts" or "field scouts," to serve as the eyes of the producer in the field. Let us consider this increasingly important vocation in detail.

What are field scouts? What do they do? They are keen observers of pest occurrence, crop development and crop/animal damage. They feed growers with detailed pest information from their fields so that properly timed pest suppression treatments can be made. It doesn't end there; they also give the grower feedback after treatments are made so that results can become a part of future decision-making. One might assume that this has always been the case in modern agriculture. But it has not, for during the '50s and '60s pest suppression was handled largely through chemical pesticide treatments (particularly for insects, nematodes and weeds) on a calendar schedule rather than a biologically timed basis. Field scouts provide farmers, themselves too busy or inadequately trained to make their own pest observations, with the necessary information to time pesticide treatments for optimum reduction of pest populations, while at the same time conserving natural pest enemies, such as parasites and predators.

A field scout's primary duties are usually to:

- Periodically survey contracted fields for specific insects, diseases, weeds, nematodes, and sometimes rodents, and determine stages of crop development and levels of damage;
- Place insect traps, spore traps, and other pest collection devices in fields to aid in detection of pests difficult to see during field visits;
- Report findings of species and levels in an organized, legible fashion to the grower or supervisor;

- Enter data into IPM computer system (or into a grower's, cooperatiave's or extension agent's microcomputer) to learn more about what detected levels and species might mean in terms of potential damage and yield loss to the crop;

- Record pest suppression treatments made during the season on a time-by-time basis, with rates and other pertinent details included, so that one year's experience can be used to improve management decisions the following year;

- Communicate with growers face-to-face about general findings from time to time so that the grower develops confidence in the scout and the reports; and

- Assist growers at the end of season in planning for the next season; certain weed or nematode problems are often spotty or localized and should be spot treated before the onset of next season, for example.

A field scout can be anyone with a keen observation skill and a grower service orientation. In many parts of the U.S., scouts come from the ranks of 4-H, FFA, vocational agriculture instructors, high school teachers, community college graduates, university graduates, and post-graduate students. Some are employed seasonally, others the year around; some temporarily, others permanently. Regardless of the situation, a field scout must:

- Possess a general understanding of the agriculture industry and its components;

- Be able to work independently and responsibly for a group of growers (employers);

- Have a general appreciation of pest life cycles and how various pests, weather and suppression treatments interact;

- Be adept at learning new materials and discerning between organisms which are sometimes very similar;

- Be able to identify many of the major insects, diseases, weeds and vertebrate pests on sight, and know how to obtain identification or confirmations of unusual finds;

- Understand how the crops or animals grow/develop, and the impacts of environmental factors on development;

- Have an ability to keep good records and communicate those records to the employer in written and oral form;
- Know how to schedule one's time to meet all field visitation obligations (Time Management is essential!);
- Be aware of the many pest-trapping devices, such as sticky traps, sex pheromone traps and fungal spore traps, and know how to use them;
- Have an appreciation of how to monitor various weather factors in and around farm fields--e.g., know how to use hygrothermometers, rain gauges, and leaf wetness meters; and above all,
- Exhibit good common sense at all times!

It is particularly beneficial for field scouts to have hands-on experience. An internship or summer placement program with an agricultural consultant or a university IPM extension specialist usually fulfills this need. Training in several of the discrete knowledge areas above can also be gained through 'short-course' (1-2 weeks) at a university. Those courses usually focus on crop and pest specifics of agroecosystems or commodities to be monitored. Since universities are closely aligned with this increasingly prominent technology, many of the needed forms, particulars and interpretations can be gained there.

What career trajectories exist for a field scout? With advanced training and a few years of field experience, an agricultural consultant role is well within reach. Consultant roles are wide and varied--most dealing with all agricultural aspects, others specializing in a few components, such as pest monitoring or cost management. Some consultants work alone with a few temporary assistants, whereas others form corporations. Training and experience as a field scout would also facilitate entry into sales positions with agrichemical or agribusiness companies. Research technicianships with university researchers would also be possible.

Training students for roles in field scouting does not require extensive special equipment. Most essential would be: a stereo dissecting microscope, pest and natural enemy specimens, examples of various pest traps and weather-collection devices, and access to a computer so that educational simulation games of how to manage pest complexes successfully under various environmental, pesticide, natural enemy and production/profit regimes can be practiced. Many educational materials are available from the Agricultural Extension Service of all states and most Services would readily cooperate in providing needed knowledge and skill training. Simulation games are freely exchanged among many universities and colleges and could be garnered for vocational education at reasonably inexpensive rates. The university could also facilitate the collection of needed biological specimens not readily available from biological supply companies.

IPM has been about 15 years in the making and really began to move into implementation during the last 6-8 years. In the next five years, there will probably be a doubling or tripling of the number of private consultants and field scouts in U.S. agriculture. Many new cooperatives for IPM will also be formed if the future is anything like the past. As farming becomes more and more dependent on the IPM approach, field scouts will be expected to do much more than monitor pests, natural enemies and crops; farmers are already wanting timely information on available nutrients, foliage analyses, and water requirements.

In the next five years, we can also project that the microcomputer will be commonplace on farms, and growers will need assistance or education in maximizing the usefulness of that technology. Software for IPM and other special farm needs will be needed and vocational education will have an excellent opportunity to meet such needs.

CHAPTER III

BIBLIOGRAPHY

The following annotated bibliography includes citations descriptive of new or emerging technologies, their diffusion, or insights as to their vocational impacts. The bibliography is the product of considerable resource effort and is judged to be a useful beginning source for those interested in increasing their awareness and understanding of relevant technologies and their practical implications.

Allen, G.E., and Bath, J.E. The conceptual and institutional aspects of integrated pest management. BioScience, 1980, 30, 658-664.

Describes integrated pest management (IPM), an alternative to simple chemical pest control. IPM is a framework for the modification of basic pest control systems by incorporating less energy-intensive, more environmentally safe methods, and capitalizing on various technologies and delivery systems.

Anson, J. H. Electronics in agriculture--electronic instrumentation: A brief review. Agricultural Review, September 1981, 62 (9), 8-9.

Brief history of development of "the age of agricultural electronics" (beginning in the late 1960's) and current applications of electronic monitors and controls for higher productivity in agriculture--includes operator benefits.

Berg, G.L. IPM: fact and fallacy. American Vegetable Grower, March 1981, p. 12.

Integrated Pest Management was developed in heal the breach between the chemical entomologist and the biological entomologist for the control of pests: (1) offered reduced use of chemicals; (2) improved public attitude toward control and (3) EPA could support IPM and be positive about it.

Dr. Perry Adkisson of Texas A&M Research Foundation head of CIPM-Consortium for Integrated Pest Management. Growers themselves are sparking crop management. ICPM-Integrated Crop and Pest Management came about as the result of a ground swell of growers demanding professional services of all types. And pest management is one of them.

Block, J.R. Research, production, marketing--fine tuning the machine. Seedsmen's Digest, August 1981, pp. 26-27.

The administration considers long-term export growth as something that is very crucial to the agricultural economy, and to the entire nation's economic health. Secondly, the area of research is considered as one of the most critical in our challenge of long-term productivity.

Agriculture is the largest net contributor to our balance of trade payments with a surplus reaching toward $30 billion. Some new developments include: a new tillage and planting system called "slit-planting" wherein a vertical slit 15 inches deep acts as a channel for plant roots. Genetic engineering has developed a vaccine effective against foot and mouth disease and promises many more profitable plant variations in the future.

Cheatham, W.J. Technology in agricultural mechanization. The Agricultural Education Magazine, July 1980, 53 (1), 8-9. Technological advances in mechanization of farm machinery and equipment and resulting changes in agricultural mechanics education are discussed. A listing is given of innovations, advances, changes: Tractor and Machinery Power--Larger, more efficient tractors. Planting and Care--Precision and accuracy in planting, cultivating and applying chemicals--(plateless planters; air planters). Harvesting Equipment--Gigantic capacity harvesters, self-propelled combines, multiple row "corn head.". Crop Processing--High capacity processing machines. Livestock and Poultry Production -- Automation: electrically powered silo unloaders, automated milking parlors. Totally enclosed hog or poultry production systems.

Groxell, W., Holcomb, E. and Bergman, E. Hydroponics: not just a pipe dream. American Vegetable Grower, February 1981, p. 28.

This article describes testing of the Skaife Pipe Dream hydroponic system for growing vegetables. A discussion is presented of the use of different growing media on growth and germination of cucumber seedlings: (1) Anything Growes Peat, plants grew larger; (2) Commercial Peat; (3) Vermiculite, plants grew larger; (4) Fine Pumice and (5) Coarse Pumice. Osmocote 14-14-14 fertilizer was used (slow release). The process is simple enough that homemakers can easily grow crops.

In a preliminary trial at Penn State, tomatoes growing in the Skaife Pipe Dream were as productive or more productive than plants growing in a traditional gravel culture system.

Haramaki, C. and Heuser, C. Plant propagation--The future is here. American Horticulturist, August/September 1980, pp. 24, 40-41.

Reasons for producing plants through micropropagation include: (1) production and maintenance of sources of disease-free plants; (2) to rapidly multiply plants which are normally slow to propagate by conventional methods; (3) to conserve space. With the advances now being made, tissue culture of plants has become one of the most significant developments in the history of plant propagation. The increasing number of new plants which can be tissue cultured, the new techniques and the better understanding of the biological processes involved are rapidly changing the methods of plant propagation used in the nursery industry.

Hartstack, A.W. Insect modeling. Agricultural Engineering, September 1981, 62 (9), 19-20.

How the integrated pest management (IPM) concept of pest control is enhanced with the use of systems analysis and computer models.

Harvey, J. It's time to join the less-till age. Farm Journal, April 1980, 104 (7), 13-15.

Conservation: Loss of topsoil is reaching crisis proportions. Conservation tillage, minimum tillage, zero-till, no-till and low-till are some terms encompassed in the "Low-Till Age."

U.S. farmers and ranchers must come to grips with soil loss -- many have already. Soil losses today are greater than during the Dust Bowl days of the dirty '30s.

Hayer, D. Computers take to the field. The Furrow, July/August 1979, 84(6), 22.

"Smart boxes" called Blitecasters recommend whether growers should spray for late blight, a fungus disease. Through sensors which measure temperature, humidity and rainfall in the field, then analyze the data, the computer predicts the likelihood of a late blight outbreak.

Henkes, R. Computers come to the farm. The Furrow, May/June 1979, 84(5), 2-5.

Article provides a description of some of the many uses to which computers have been or can be put by farmers. Balancing books; planning crop rotations; fighting pests; scheduling workdays/field operations; controlling light, temperature and humidity in farm buildings; operating sprinkler system automatically; running food processing equipment.

Sharing of information via computer terminal such as through Project "Green Thumb" sponsored by the Federal Extension Service, the U.S. Weather Service and the University of Ken tucky, includes county weather forecasts, market reports and analyses and information on fast-changing technical matters such as the disease and insect situation in crops.

Access to data bases could be an issue of the future.

Hexagons, computer models hold promise for small farms. Seedsmen's Digest, January 1981, pp. 46-47.

The hexagon is, in some ways, the shape of things to come for small farms around the world. Hexagonal plantings are being used at Michigan State University's Agricultural Experiment Station as a means to gather information about growing systems of crops raised simultaneously in shared, limited space. All information essential to growing the crops (weather--sunlight, temperature and rain, and nutrients and soil moisture) is fed into a computer and different combinations of variables are then programmed to find which conditions will produce the best harvest and predicting yields. This technique of computer modeling or simulation of growing systems will provide a new and speedy method to generate specific and detailed information on how to produce maximum harvest in virtually any crop. Literally years of field trials may no longer be necessary.

Hill, D.A. The face of the future--Agriculture. VocEd, January/February 1982, 57 (1) pp. 35, 83.

Farms of the future will be transformed by advanced mechanization, telecommunications, energy conservation and genetic plant research. Larger, lighter, more powerful equipment will reduce fuel consumption, will be self-steering and self-adjusting and safer to operate. Computers will be involved as controllers, monitors, sensors, business aids, information links and in numerous other ways aid efficient farm practices. Natural resources such as sun, wind and farm by-products will be used to generate energy. Emphasis on conservation of soil and water will involve equipment changes, irrigation and tillage practices, new production techniques and re-cycling of waste water and by-products of farming. Genetic engineering of plants will bring new, more nutritious crops.

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Production changes will be necessary in the 80's. Some changes will relate to energy use, efficiency in using pesticides, herbicides, plant nutrients and growing media. New kinds and types of plants will become available and will be used increasingly for traffic control, crowd control, security, energy saver, sound barriers and dust and dirt filters. The industry will utilize computer technology for information, business management and production.

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This article contains a description of the procedure for growing vegetables hydroponically and a discussion of companies/research units involved in the process, including the demonstration project being set up at Disney's EPCOT (Experimental Production Company of Tomorrow) by the University of Arizona's Environmental Research Laboratory, Kraft Corp. and the Disney Corporation.

Kessler, K. It's not nice to fool with mother nature...or is it? The Furrow, April 1979, 84 (4), 2-5.

This article gives descriptions of procedures including nitrogen-fixation research, photosynthesis, recombinant DNA, tissue culture, test tube chickens, cell-fusion and cell-free agriculture. Benefits and implications for filling needs of the future are discussed. "If future generations are to feed themselves, scientists will have to learn many more of nature's perplexing ways and figure out how to improve on them." (author)

Making the switch to drip. American Vegetable Grower, April 1981, p. 12.

Trickle (drip) irrigation of tomatoes is discussed. Description given of irrigation systems; comparison made to overhead irrigation. Report of increased yields, energy savings, reduced need for heavy fertilization and fungicide treatments. Weed control is easier; harvesting can continue during irrigation. Drip irrigation and plastic have made double-cropping possible.

Micro-propagation. American Vegetable Grower, April 1981, p. 59.

A recent propagation technique that has been explored at various places including the University of Wisconsin, is called micropropagation. This is simply a method of rapid multiplication of plants in a sterile "test tube" environment. Very rapid increases in disease-free cloned plants can be achieved independent of such things as weather and field conditions--from 20,000 to millions of plants can be generated annually using only a square foot of shelf space!

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Discusses various measurement/control functions of instrumentation which are made possible or enhanced by microprocessors. Included are "intelligent" chromatographs, characterized pH controllers, safety warning systems, compressor control, combustion control, energy management, portable psychrometry, battery chargers, navigation and vehicle monitoring systems, automated test equipment. Gives technical references.

New horizons in water management. American Vegetable Grower, April 1981, pp. 14-20, 44-45, 48.

The water crisis facing the U. S. may be more severe than the present energy crisis. Growers must conserve existing supplies through efficient cultural and irrigation practices. Irrigation accounts for 81 percent of all water consumed in the U.S. and 53 percent of irrigation water comes from groundwater supplies.

Trickle (drip) irrigation shows a lot of promise as a conservation method, especially when combined with plastic mulches. Transplants are also being used to save when watering seedlings. Dead levelling of fields (with laser beam levellers) makes it possible to control water flow. Low Energy Precision Application (LEPA) modifies a center pivot system and reduces water usage.

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This article describes procedures and various recycling and uses of animal wastes. This is not a "new" idea, but a return to old technology with new applications, procedures, etc. Waste Management: Use of animal waste in farm ponds to grow algae to feed hogs and fish and grow water chestnuts. Treated and composted to feed cattle and dehydrated and used as fertilizer.

Plant breeders report latest research findings. BioScience, 1981, 31, 488.

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Pratt, M. Will that compute? Agricultural Engineering. September 1981, pp. 10-11.

Article provides descriptions of applications of computers in agriculture, agricultural research, agribusiness and industry: (1) John Deere Dealer Audio Response Terminal System (DART); (2) Farm records--feed consumption and production, etc. (listing given of numerous practical on-farm computer uses); (3) Research on remote water and energy management system (WASC); (4) Microprocessor-based data acquisition systems; (5) Inventory control--by industry; (6) CAD/CAM for designing equipment; (7) Potentiometers for automotive and field-equipment operations. Among practical, on-farm computer uses mentioned are: financial and business records; management decisions, including market information and production records; automated production, monitoring and process control, including equipment monitors; equipment guidance; environmental control in confined animal and plant production systems; automatic control of materials handling; and optimal control of other energy-dependent processes.

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New Irrigation Technique--Comparison of three irrigation methods: (1) electronic feedback from weather station; (2) direct electronic soil moisture readings and (3) furrow irrigation. Description of research on types of irrigation and reporting of outcomes. Trickle irrigation product yields were considerably higher when water amounts were accounted.

Rich.., C.B. Innovations in planters and seeders. Agricultural Engineering, February 1981, 62 (2), 16-17.

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Ryther, J.J. Mariculture, ocean ranching, and other culture-based fisheries. BioScience, 1981, 31, 223-230.

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Among the important topics today in biotechnology are: monoclonal antibodies, tissue culture, and recombinant DNA which are defined and discussed briefly in this article. There are exciting prospects for the future in biotechnology.

Agriculture, with its diversity of crops and livestock, has a real investment in genetic engineering. Plant breeders are the original genetic engineers.

Smith, L. A. and Schafer, R. L. Automatic guidance for agricultural machinery. Agricultural Engineering. September 1981, 62(9), 12-14.

Article discusses the potential for automatic guidance of agricultural machine systems. Description given of feasible guidance system which has been tested by a team at the National Tillage Machinery Laboratory at Auburn, AL (USDA-ARS engineers). Missing link--a suitable spatial position sensing device for accurately locating the machine in the field.

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Hydroponics, or growing plants in soil-less materials or a nutrient solution, often works better than growing them in soil. The plants don't know the difference. Hydroponic installations are more expensive than field culture, but many greenhouse operations are turning to hydroponics or other soil-less propagation methods.

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There are two general types of food production technologies for the future--mechanical-labor-saving and land-resource-intensive, on the one hand, and biological-chemical or land-resource-sparing, on the other hand. The future will show a worldwide shift from less of a natural-resource based to a more science-based agriculture. The emphasis will be to raise output per unit resource input and release the constraints imposed by relatively inelastic supplies of land, water, fertilizer, pesticides, and energy.

It is projected now that almost all future increases in food production will be a result of increases in yield (output per unit land per unit time) and from growing additional crops during a given year on the same land. There are really no other viable options. Greater investments in research offer our principal hope. (author)

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