Engineering
For A Competitive North Dakota Agriculture

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Engineering systems for the agricultural and biological sciences are needed to provide safe, effective agricultural production and commodity processing to meet international competition. People of the world have looked to the United States as a major supplier of food and other agricultural commodities. Today effective production of agricultural commodities has reached many parts of the world. Markets without competition are decreasing in number.

Research today is being oriented toward efficient and safely designed engineered systems for competitive production of agricultural commodities and for processed agricultural products demanded by domestic and foreign consumers. As soon as new engineering developments are made public, they may be adopted around the world. Research must continually move forward to refine production and processing systems and to assist with development of new products that will keep agricultural production in the United States ahead of the competition.

Technologies being developed for the military and for industrial enterprises can be adapted to equipment needed for agricultural production and processing. Agricultural engineering systems research must be accelerated to work toward optimizing equipment design and utilization.

Computerized systems analysis, computer-aided design of equipment, functional requirements of machines and effective crop and livestock production techniques are examples of contributions engineers can provide for solving the problems. Sensors and computers are now used in the field. Expansion of their use may lead to improved efficiency in many production and processing operations.

Machine vision is a technology that is here today and offers wide application to agricultural production and processing. Machine vision systems typically include a video camera and a computer system that acts as an image processor and system controller. The machine vision system can detect defects, specify the location, or determine the size of objects in a processing operation. Examples of the use of machine vision are inspection of products on processing lines and sizing fruit and vegetables being sorted, cleaned, and graded.

The U. S. Air Force has a Global Positioning system partially operational at the present time. Twenty-one satellites will be spaced in orbit to complete a basic navigational system. The system also provides for accurate location of sites on earth and is being used as a tool for ground surveying. The system, coupled with automatic guidance and variable rate planters and fertilizer applicators, can make possible the optimization of plant populations and fertilizer application for plant needs and water availability.

Transmission of signals by fiber optics offers opportunities for better transmission of electronic signals than is obtained with wire cable. Electronic signals are converted to pulses of light which are then transmitted through fiber optic cable. The modulated light beam is then converted back to an electrical signal at the receiver. Data from sensors can be transmitted to computers by this means with greater accuracy over longer distances and with less interference.

Transmission of electronic signals through the air using infrared light beams is also being used in engineered systems. Data collected from sensors can be transmitted more easily from the field using infrared than if wire is used. This technology gives reliable signal transmission over limited distances. The system eliminates the need for placing a network of wires in fields where they may interfere with tillage and other operations. An example of this technology is the use of infrared light beams to transmit signals from soil moisture sensors to computers. Laser beams can be used in a similar way and are reliable over longer distances. Lasers are in use today for controlling land leveling equipment particularly in the Red River Valley. In this application, it is part of the sensor system. The beam is used only to indicate if a receiver is above or below a predetermined elevation. In response, the leveling control equipment is activated.

Robots are being evaluated for milking cows in many parts of the world. Computers are programmed to control robots designed to locate and determine the shape of a cow's udder. Robotic milkers are now under test but will require further development before they can be made available commercially. Electronic identification sensors are now being attached to cows so that data such as feed consumption and milk production can be automatically recorded in computers.

Water balance irrigation scheduling methods have been developed in North Dakota. This technology is being adapted to automating irrigation management to make more efficient use of irrigation water possible. These management systems will use data that are transmitted from sensing units in the field to a computer located at the farmstead. Data analyzed by the computer in turn will be transmitted back to the irrigation system to start and stop the unit automatically. The data inputs required for the prediction of the need for irrigation water applications include solar radiation, rainfall, temperature, and crop curves. These crop curves have been generated from data collected from the fields over a period of several years. Sensors are used to collect the remaining data needed to activate the system.

Upgrading food products, developing agricultural based industrial feedstocks, and biotechnology all can be used to develop new uses of crops. Biology specialists and agricultural engineers will be called on to develop these new products. Engineers can serve this industry by providing expertise on heating, refrigeration, drying, cleaning, sorting, materials handling, storage, fermentation, extrusion, extraction, enzyme processing, fluid mechanics, packaging, machine design, power application, environmental design, water treatment, waste disposal, electrical application, sensing, and control.

Much time, money, and effort are put into planning, preparing, seeding, fertilizing, and protecting the agricultural crops produced in North Dakota. However, during and after harvest, many crops are not given the same level of attention they receive prior to harvest. In order to maximize profits and to be competitive, not only must high quality commodities be produced, but all that is produced must be harvested without decreasing quality. That quality must then be maintained until it is ultimately processed or consumed.

North Dakota ranks high in the production of over a dozen different crops. Research is needed in the areas of efficient harvesting and conditioning of these crops and on what effect the conditioning processes have on the quality of the product.

Crop drying capability has resulted in a move away from swathing and into straight combining. This results in less field loss and crop exposure to weather while on the ground. Labor, equipment, and operating costs required for swathing are eliminated, but crop drying can have some negative effects on quality and processing yield. Research on corn has shown that some drying procedures can cause stress cracks, which may result in a product which is further damaged in handling or is unacceptable for its intended end use. This research can be applied to other crops.

Developments in biotechnology are introducing a wide range of engineering challenges for those trained in both engineering and the agricultural and biological sciences. Dr. N. R. Scott, director of the Cornell University Agricultural Experiment Station has pointed out that biotechnology will not change the basic purpose of agriculture, which is to produce food, fiber, timber, and chemical feedstocks. He goes on to say that new techniques for manipulating the genes of plants, animals, and micro-organisms will complement traditional methods used to enhance agricultural productivity.

Engineering challenges exist to increase the speed and improve the accuracy of injection of DNA directly into single living cells. Bacterium may be altered genetically to produce antitoxins that will control insects and other pests. Engineering opportunities exist for utilizing these bacterium as field sprays or in seed coatings. Spraying equipment can also be used to apply the genetically altered bacteria that deter formation of ice crystals to prevent frost damage to crops.

The stomata of plants provide for movement of gases and water vapor through the plant leaf. Engineers have used finite element analysis to understand the opening and closing of stomata. Control of these stomata could affect drought resistance of crops.

Animal embryo transfer, cryo preservation of sperm and embryos, and sorting of x and y chromosomes are other examples of developing technologies Dr. Scott identifies as having many opportunities for engineering research.

Harold J. Schramm, manager for implement engineering for Case, I. H., recently said that engineers in public research institutions may serve producers and equipment manufacturers best by providing reliable design criteria for development of efficient machines. This complex work requires input from potential users along with systematic engineering analysis. With this information, manufacturers would be able to produce machines that are appropriate for use in the field.

A computer-operated gantry operating over plots of land to carry out field operations from tillage to harvest is under test. Wheels at each end of the gantry run on tracks or compacted soil paths. The overhead trusses span the space between the wheels and are used to suspend implements such as rotary tillers, pest control equipment and a harvester. Signals are transmitted from a central computer through fiber optic cables to minimize interference to electronic signals. Electricity may be adapted to these units as a power source. Greater precision in control of tillage, planting, and harvesting systems may be achieved with the system. Soil compaction may also be controlled. Costs of the gantry currently exceed cost of conventional equipment, but added research may improve the economics of the system.

Diesel engines with improved efficiency are under development and can be adapted to agricultural tractors. Today's engines utilize only about one third of the heat energy of the fuel to produce work. The remainder is lost through exhaust gases and cooling system. New ceramic materials are being built into engines to make it possible to operate them at higher temperatures. Insulation to retain engine heat, recovery of heat from exhaust gases, and heat resistant lubricants are under development for use in these ceramic engines to improve operating efficiency. These adiabatic diesel engines show significant promise of converting a major part of the heat energy of fuels into useful work.

Agricultural engineers are developing automated controls for a combine. Several sensors, including devices to measure grain loss from the sieves, are in common use. Electronic signals from sensors of this kind are being sent to a computer which in turn can send signals for control of appropriate components of the combine. Ground speed, concave clearance and air flow rates are examples of components that can be controlled automatically. Electrical, mechanical, and hydraulic actuators effect control of these components. Major developments in sensor, computer and control systems will be needed before commercial units can be made available.

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North Dakota will likely become even more important as a potato producing state.

Field Windbreaks and Farmstead Shelterbelts. If indeed the climate in North Dakota becomes more arid, the use of field windbreaks will become more important. The management of tree plantings will become more intense with thought to developing stands that will not only serve the usual purposes of conservation and protection, but will also serve as an income source for the farmer.

The production of sawlogs from plantation stands of oak, walnut and elm may well become the only source of these hardwoods. Managed windbreaks of poplars could become a source of fuelwood and rough lumber. Pines planted on a rotation plan could supply Christmas trees and poles.

Seedling trees for future windbreaks and shelterbelts will be produced from seed from seed orchards made up of superior strains that are known to produce vigorous, fast-growing, productive trees. Future trees could also be produced in tissue culture from known supertrees that are superior for a particular use. They also may be genetically engineered for resistance to disease, insects or environmental stress factors. Certainly we will have trees more in tune to the conditions of their use.

Ornamental Plants. As North Dakota emerges into its second century and the nation into its third, the value of a more aesthetically pleasing world is apparent. There have probably been more arboreta and botanical gardens started in the U.S. in the last 20 years than in all the history of our country. This trend will continue. Not only are these areas interesting, but they are necessary for a mature and growing population.

The urban forest that makes up our cities and suburbs will continue to receive emphasis. These parks and boulevards present a whole new set of problems requiring research. This is a valuable asset and its necessity will become more apparent as time passes.

Ornamental plants involve not only the plants and man but the interaction of man with the plants and man's relationship to his environment. Thus, the research involves not only plants, but also the interactions of plants and man and how they live together in the twenty-first century.

Home Horticulture. The number one recreational activity in the United States is gardening. North Dakotans are not an exception to this. Home vegetable gardening will continue as a hobby and a means of providing high quality produce. As the new technologies and genetic engineering are used to better commercial crop production, the home gardener will also benefit.

The older cultures in Europe and Asia foster the hobby of plant culture for both food and beauty. It is to be expected that this will also be true in the United States. Much as interest has increased in public gardens, home gardening holds a fascination for many people. This will increase. With both an increase in popularity and population, research to service the home horticulturist will provide many challenges in the future.

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Systems for utilizing on board computers are being developed to optimize tractor performance. A series of sensors can be used to measure factors such as fuel consumption, power requirements, and ground speed. Continuously variable transmissions may be incorporated into tractors to facilitate computer control based on sensor input. Fuel efficiency is a major variable that may be controlled in this way, but the system could be adjusted for other factors such as maximum work rate in emergency situations. Sensors and computer control systems are commonplace in today's automobiles, tractors and farm implements. Expanding these uses is likely to replace much of the manual control equipment still in use.

New engineering technologies that may adapt to agricultural production and the processing of agricultural commodities are continually being developed. Some may be utilized in ways that will improve the competitiveness and safety of agriculture while others may not. These technologies must be considered as potential improvements for economic production and use of agricultural products. Agricultural engineers can evaluate and incorporate appropriate options in ways that will help make North Dakota agriculture competitive in the World.