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Research in Physical and Biological Science and Engineering In Relation to Agricultural Policy

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The technology which has enabled producers in industrialized countries to double crop yields during the past generation is the product of research.

Increased yields in industrialized countries have enabled them to keep vast areas in grass and trees that, at lower yields, would have been required for harvested crops. Developing countries can, through the wise use of technology in agriculture, contribute to their own economic development, provide food for their increasing populations, and retain grasslands, forests and wildlands for game, recreation, and other uses.

Research in the physical and biological sciences and engineering has produced materials, methods, and equipment. Research in the social sciences has evaluated the economic and social costs and benefits of the use of technology, including the modification of policy and development of new policy as a result of the adoption of technology.

Some of the policy goals involved are:

1. Assurance of farm income and an abundant food supply at reasonable prices to consumers.
2. Conservation land use and use of associated water with due regard for productive capability of the land and its location.
3. A safe and wholesome and nutritious food supply, free of harmful amounts of chemicals, toxins, and microorganisms.

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4. Protection of man and his environment and crops, livestock, forests, fish, and wildlife from pests--insects, diseases, parasites, weeds, and others.
5. An environment of high quality for man, for his enjoyment, and for future generations.

There are about 10,400 scientist man years devoted to research on agricultural problems in the Department of Agriculture and cooperating research institutions. About 13 percent of these are social scientists, about 53 percent biological scientists, about 22 percent chemical scientists, about 9 percent engineers, and about 4 percent physical scientists.

I will tell you briefly about some of the important achievements and problems in major areas of research and conclude with a brief discussion of their relation to the five policy objectives I have stated.

Soil and Water

Soil capability for agricultural and nonagricultural uses and the necessary fertilizer amendments, the management practices, including water management, are essential to the conservation use of our soils. Conservation use is based on the principles of optimization of multiple uses for public benefit as well as beneficial use by the proprietor.

Water is often the limiting factor in crop, forest, or grassland productivity. Water management for efficient use includes the technology of crop selection, land treatment, water management structures, irrigation and drainage. Desalinization of brackish or salt waters is technologically feasible but under most conditions presently uneconomical for agricultural use.

Since much of the water falling on any area is lost by evaporation from the soil surface, covering most of the surface with impervious material. For example, plastic may save water for crop use.

Plants vary widely in their water requirements, depending on temperature and stage of growth. Experimentally, it is possible to retard transpiration loss of water by using chemicals which close the pores (stomates) on the leaf surface.

Efficient use of water is greatly increased by its application according to plant requirement. Devices are available for quick measurement of available soil moisture to determine need.

Other essential measures for effient water use are optimal rates of fertilization balanced with available water and selections of crop species and genetic stocks which give highest yield response in particular soil, water, fertilizer, seasonal and climatic situations.

Land forming (use of level terraces) permits infiltration of water into the soil rather than runoff. Such terraces yield only about one-seventh as much sediment as untreated similar land.

Crop Production Research

Research to increase yields, to improve quality, and to adapt grain, oilseed, cotton, tobacco, fruits, and vegetables to mechanized production continues to offer major needs and opportunities for research.

Among major recent research achievements in this area is the development and adoption of dwarf hybrid grain sorghums which have added greatly to yield and reliability of this short-season grain crop.

Semi-dwarf wheats of high yield capacity under favorable water and fertility conditions have been developed by Vogel and his co-workers in

Washington State. They began with the importation by Salmon in 1946 of dwarf genetic material from Japan. These genes were also used by Borlaug in developing semi-dwarfs which are contributing to high yields under irrigation in Mexico, India, and Pakistan.

A highly important achievement by Mertz and his co-workers at Purdue is the development of maize with high lysine content. Unlike other corn, high lysine corn contains protein biologically adequate for the nutrition of monogastric animals (pigs, chickens, and man himself).

Mechanization, largely achieved by engineering invention in industry, has provided the average U.S. farm worker with about 45 mechanical horsepower to help him in the timely tillage, planting, and harvesting of crops.

Research in USDA and the State Agricultural Experiment Stations has contributed in concept, design, and development both of machines and in adaptation of crops to mechanization. An outstanding example is the development of a mechanical harvester for processing tomatoes and of tomatoes which were adapted to a single mechanical harvest in California.

Livestock Research

Genetics, nutrition, physiology, and animal disease research continue to contribute to the increased efficiency of production per animal breeding unit and per pound of feed used. Milk production per cow and egg production per hen have been nearly doubled during the past 40 years through the application of information gained through research. The amount of broiler or turkey produced per hundred pounds of feed used has been increased by more than half. Gains in feed efficiency in swine have been modest and those for cattle and sheep small.

Animal disease research has given us methods for eradicating brucellosis in cattle and cholera in swine. Protection against Marek's disease (paralysis), a principal poultry disease, seems likely through use of a new vaccine.

Our Plum Island Animal Disease Laboratory and research supported outside the U.S. are contributing information and better immunizing methods against exotic diseases such as foot and mouth disease (aftosa) and rinderpest.

Research on reproductive physiology has extended the successful use of artificial insemination. Use of hormones to control time of conception continues to show promise.

Protection Against Pests

Research on protection against pests, always a major research area, has been reemphasized recently by the necessity for restricting the use of such persistent pesticides as DDT and mercury and by the heavy loss suffered in 1970 from the maize disease called "Southern Corn Blight."

We depend upon genetic resistance in crop plants for protection against cereal rusts, and against such pests as Hessian fly and wheat stem sawfly and certain alfalfa aphids. We have partial genetic protection against blight of tomatoes and potatoes.

Cereal rusts continually develop new populations pathogenic for resistant cereals so that new genetic stocks resistant to these newly emerging pathogenic populations must be sought continually. We cooperate in this search with many countries of the world.

Southern Corn Blight is caused by the fungus "Helminthosporium." It affected a major portion of the 1970 maize crop, causing a loss of about 20 million metric tons in yield, a sixth of the anticipated crop.

The susceptible maize carries a gene, the Texas cytoplasmic male sterile, put there by geneticists so that hybrid seed could be produced without the labor of detasseling the male parent. Now that gene must be replaced by one resistant to the virulent Helminthosporium. Cooperation in Latin American countries is helping to produce a seed crop during our winter so that we may have more resistant seed available next year.

Protection against insect pests depends heavily on chemicals but important effective biological,cultural and integrated control systems are resulting from research. Alfalfa weevil in the Northeastern United States is largely controlled by parasites, the Screwworm fly by radiation-sterilized fly release; the pink bollworm in the Lower Rio Grande Valley by strict, early destruction of crop residues.

Interspersed alfalfa, preferred to cotton by lygus bugs, is an essential part of an integrated control system for cotton insects enjoying some success in California. Alfalfa interspersed fields require less chemical treatment to control lygus bugs and thereby predators and parasites of the cotton bollworm are spared to control that pest.

Food Technology Research

Food technology research continues to produce a diverse array of convenience foods. Such foods enable the working mother to prepare

attractive meals quickly and with minimal labor. Net cost is increased but little over preparation from the raw materials.

Development of dehydrated potato granules which can be quickly reconstituted, and of frozen orange juice concentrate are among major achievements.

Food technology also develops food substitutes such as cyclamate sweeteners which have lately run into trouble because of their effects on test animals.

Food technology, by segregating soy proteins, developing meat-like texture, and adding meat-like flavor is developing acceptable meat substitutes.

Such substitutes, and natural products too, can be, and to a limited extent are, fortified with trace minerals such as iodine in salt and vitamin D in milk, and experimentally with amino acids such as lysine and methionine.

Food Protection

Research provides the procedures and materials required to protect our food supply against microbes and the toxins some of them produce, against chemical contaminants, insects, and loss in quality due to metabolism or dehydration during storage.

Effective fungicides, antioxidants, fumigants, and insecticides must all be used within tolerances established under our Food, Drug, and Cosmetics Act.

Research has achieved substantial success in developing methods for the elimination of aflatoxin from peanut food products and of Salmonella from egg and milk products.

Research continues seeking methods for eliminating Salmonella from our poultry and meat supplies.

Research has achieved success in controlled temperature and CO_2 storage for fruits keeping their fresh quality for months.

Dehydration is prevented by appropriate, research developed, packaging and coating materials applied to such products as vegetables and eggs.

Human Nutrition

Research in the area of human nutrition has benefitted from the much broader based research with laboratory and domestic animals. But extrapolation from animals to man must be tested by adequate information gained with human subjects.

Much of the information on human subjects consists of data on nutritional status and correlation studies between such data and data for human mortality and morbidity.

In specific areas such as vitamin, mineral, and amino acid requirements, qualitative knowledge is fairly adequate. In all areas, quantitative information is less than adequate.

Our knowledge of the interaction of nutrients is not adequate. For example, the kind and amount of carbohydrate may influence the effects of the kinds and amounts of fats in the diet. Certainly requirements for some of the vitamins are partially dependent on the kinds and amounts of various nutrients in the diet (as well as on age, sex, and physiological condition of the individual).

Current research on human nutrition in the United States is designed to determine qualitative and quantitative nutrient requirements for various ages, sexes, and physiological conditions especially preferred by low income people or those with other special concerns.

A great deal of attention continues to be given to the relation of diet to cardiovascular disease. More than half of all deaths in the U.S. occur from this cause. Overweight is associated with high blood pressure and diabetes. High blood sugar is associated with stroke. High blood cholesterol is symptomatic of cardiovascular risk. It may be reduced in some individuals by reduction in the amount of fat in the diet; in some by increase in the amount of polyunsaturated fats in the diet; in some by changing the type of carbohydrate in the diet.

The United States is a nation of meat eaters and milk drinkers. Our intake of saturated fatty acids is high. During recent years, our diet has contained increasing amounts of vegetable fats, displacing butter and lard. But much of the vegetable oil is hydrogenated (a means of changing unsaturated to saturated fat).

Environmental Quality

A major objective of agricultural research is the protection and enhancement of the quality of the environment, especially of the human environment. Agricultural research, while primarily directed to the quality of the rural environment, contributes very substantially to the urban environment, too. Agricultural and forestry research has identified trees, shrubs, and flowers, and grasses that best tolerate the urban environment.

Management of city forests and parks based on forestry research information can provide wildlife habitat and continuing beauty. Selective harvest of senescent trees and their orderly replacement by young, genetically superior stock can continually enhance cities.

Research on soils yields information valuable to construction and urban water management. Research on land treatment and water management on rural lands can lead to the reduction of sediment deposited in urban reservoirs.

Pollution

Pollution in relation to agriculture includes the effects of pollution on agriculture. Examples are weather fleck in tobacco caused by ozone of traffic or industrial origin (or from lightning), fluorine from phosphate or steel plants and from water of impaired quality often resulting from repeated use for irrigation.

Pollutants produced by agriculture include pesticide chemicals, nitrates carried by leachates from cultivated soils or feedlots, phosphorus carried on sediment into lakes and streams, burning of forest and crop wastes, food processing wastes, odors from intensive livestock enterprises. Many rural communities still lack sewage treatment facilities and septic tanks are often ineffective.

Research in USDA and the State agricultural experiment stations has developed effective means for managing animal wastes by aerobic decomposition and by holding ponds pending distribution to the land. Research indicates that careful, moderate application of such wastes to grass, woodland, or growing crop on suitable soils can provide an effective filter for removing plant nutrients and returning water of good quality to groundwater. The land can, with adequate research based technology,

beneficially accept sewage sludges from our cities and composted wastes. There are hazards to be removed, including possible contamination with such toxic metals as mercury and cadmium.

There is concern over pollution of our waters with agricultural chemicals. Research has demonstrated that gill filtration by bony fish and shell fish concentrates organochlorine pesticides and mercury from parts per trillion in their ambient water to parts per million in their fat or flesh.

Nitrates in our waters are one factor in eutrophication. While blue green algae fix their own nitrogen, green algae and other water plants respond to increased nitrogen. In most localities the bulk of nitrogen comes from city sewage and animal wastes. However, nitrates may leach from all bare, warm soils when sufficient water is added. It makes no difference whether the nitrate comes from soil reserve, crop or livestock wastes, or chemical fertilizer, some does come from the land. We have doubled nitrogen fertilizer used during the past 10 years and further increases will, in many cases, bring favorable yield responses.

Research on management of forest wastes has shown that in some burned areas, mechanical maceration can lead to accelerated biodegradation. In other areas, fire is the management tool of choice but there is resultant air pollution.

Fire is also used to control diseases and insects on grass seed fields in the Northwest and alternates are sought through research.

Forest Production

Research in forest production includes genetic selection and development of superior stocks of trees for timber, pulp, shade, and other uses.

Research on methods of fire protection, of harvest, of reseeding, and stand improvement have provided information which is used in production technology which continually improves the productivity of our forests and woodlands.

Research on forest production gives equal emphasis to timber production and other uses of forest lands including wildlife habitat, for water harvest, for recreation, and natural beauty, items covered in this presentation under environmental quality.

It is estimated that research based technology can increase timber production by 60 percent while at the same time increasing productivity of water, grazing, wildlife habitat, recreational wilderness, and other values.

Discussion

The five policy goals--income and abundance, multiple and conservation use of land and associated water, a safe and wholesome food supply, protection against pests, and protection and enhancement of the environment--are all served by research on crops, livestock, forests, soil, and water. The contribution of production efficiency to abundance is obvious. The relation of efficiency to farm income continues to command the attention of social scientists and policy makers but most of all the producers. Many of them are disadvantaged by competition of the more efficient.

Research in these basic fields of agricultural research has only lately been focused on the problems of waste management and pollution resulting from large livestock enterprises, crop and processing wastes, forest slash and other forest wastes, and contamination of water and non-target organisms by chemicals.

Pest protection continues to be a major problem rendered more difficult by necessary restrictions placed on the use of pesticide chemicals because of hazards demonstrated from the use of some of them.

On the positive side, all phases of agricultural research contribute to the quality of the environment. Higher acre yields of crops and high yields per animal breeding unit of livestock releases vast acreages for grass and trees and open space that would be under cultivation at lower yields. Soil and water conservation research and forestry research provide the information necessary for land use according to capacity and for compatible multiple uses.

The research on food technology, food protection, and nutrition are basic to the good nutrition which our people, and all people, must have to achieve and enjoy a better environment.

We are considering under the policy established by the National Environmental Policy Act of 1969, the environmental impact of the results of all of our research with highest priority on achieving a better environment.