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AGRICULTURAL RESEARCH IN THE WAR AND AFTER[1]

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RESEARCH workers in our State agricultural experiment stations, in the Federal Department of Agriculture, in universities and other research and educational institutions and in industry have faced a tremendous challenge during this war. That they are meeting it successfully is witnessed by the result—an unprecedented agricultural production, the development and utilization of new foods, drugs, fibers and strategic materials of many kinds; improved methods of distribution, packaging and processing of agricultural products; and increased knowledge of requirements for foods and other products needed in everyday living. These results have been made possible by utilizing the materials and knowledge accumulated through scientific research, as well as by effective organization for developing new knowledge to meet emergency needs. Scientists in all fields related to agriculture are playing an important part in this work and will play an even more impotant one in the future. Just as great a challenge awaits research in the post-war world as it faces now. By continuing to work together we shall be able to meet it.

But an overwhelming number of demands tumble upon each of us these days. In the complexity of details it is both difficult and important to keep the major problems clear and if possible see the general direction in which we are moving. So the question I wish to propound this morning is: What is the real value of the agricultural and related research work being carried on year after year in the form of thousands of big and little projects? We know that it is helpful to solve a lot of individual problems—but what do such solutions contribute as a whole for this nation and for mankind?

This question can be divided into three parts: What has agricultural research done in the past? What is it doing now? What can it do in the future?

[1] Address given at the fifty-seventh annual convention of the Association of Land-Grant Colleges and Universities, Chicago, Ill., October 27, 1943.

I realize that it would take many books and the knowledge and wisdom of many minds to answer these questions fully. I shall suggest only a few of the answers.

Research Shaped Our Civilization

If this meeting were being held in 1787, the year the Constitution was written, we would probably be a gathering of farmers. Nineteen people out of every twenty in those days lived on farms. Nineteen farm families could produce only enough surplus, beyond their own needs, to feed and clothe that one non-farm family. But we are meeting in 1943—and I assume that there is not one of us in this room who devotes himself exclusively to farming. Many of us came from farms originally (and some of us would like to be back there again). But we're not on farms—in fact, there are now only about four farm families in this country to each 20 non-farm families. China still has 19 farm workers to one non-farm worker—exactly where we were in 1787.

The conditions that have made it possible for so large a proportion of our families to be released from the necessity of being on farms have also made it possible for us to have in the United States so many roaring steel factories—networks of railroads—airplanes—automobiles—telephones—refrigerators—business and professional services of all kinds—and to turn out such huge quantities of material for ourselves and our Allies in this war. A comparatively few farmers can produce enough to feed and clothe many other people who can work in offices and factories and laboratories because they are not required to produce food and fiber directly for themselves.

These facts are generally known but are so elementary that we overlook them. I review them here because they summarize, more strikingly than anything else I can think of, what agricultural research has done and made possible in the past. It has increased agricultural efficiency, step by step, year by year; and that in turn has played a large part in enabling us to build and operate great industries.

It would be absurd and untrue, of course, to say that only research directly connected with agriculture has made our industrial development possible. Progress is based on the exchange of knowledge developed in many fields. But the fact remains that the research of the land-grant colleges, the State experiment stations, the U. S. Department of Agriculture and our universities and other institutions dealing more or less directly with agricultural and related problems has not only paralleled but to a large extent stimulated the great progress in agricultural efficiency made in this country since 1860—progress that helped make our industrial civilization possible. And our agricultural institutions have not been content with doing a vast amount of productive research; they have carried the results directly to the farmer and have shown him how to apply them, thereby cutting down the time that would otherwise be required for the adoption of new practises.

We are not going to stand still where we are. I believe that the possibilities for advance in the coming decades are at least as great as the achievements of the decades that are past. But we will not have these advances unless we maintain and in fact increase our agricultural research. In a civilization making such full use of applied science you have to run fast to stay where you are. If you want to move ahead, you have to run still faster.

The Underpinning of Wartime Production

It is unnecessary to recall to this audience that after World War I there was a period of pessimism about research, especially during the depression, when there were huge surpluses of some farm products. There was a feeling that somehow research was at least partly to blame for those surpluses. It had shown us how to grow two blades of grass where one grew before, and now we apparently didn't need the second blade; no one wanted it, and it was a burden and a curse. With farmers experiencing such hard times, and many of them being driven out of business, some scientists wondered whether they were performing any really constructive function, and at times they were even made to feel rather uncomfortable.

The one good thing about the depression was that it finally drove home to many people that fact that those surpluses were not surpluses at all in relation to our needs, and certainly not in relation to world needs, since at least half of the world's people are not properly fed. The true situation was that scientific progress was far ahead, temporarily at least, of economic and social progress. We knew how to produce, but not how to get the products to the people who needed them. We did not know how to maintain what the economists call "effective demand."

Then came the present war. Incidentally, many think that modern war also is fundamentally due to the fact that economic and social progress have been unable to keep pace with scientific progress. But the war has completely reversed any feeling that we knew too much about how to produce. It automatically did what we were not wise enough to do in peace. The war created "effective demand," in terms of astronomical figures. And mark this point well—we could not have met that demand if it had not been for the advances our farmers have made in production on a scientific basis during the past few decades, coupled with the ability of those organized to serve the nation

—agronomists, horticulturists, soils experts, economists, entomologists, botanists, pathologists, agricultural engineers, biochemists, home economists, dairy and animal husbandmen, extension specialists, administrators, and others in many specialized branches of science—to mobilize and extend our resources quickly to meet new emergency problems. In very large measure, we were ready, and all these fields have been called upon and many individuals utilized in far greater measure than can be disclosed until peace has been restored.

MOBILIZATION OF RESEARCH FOR WAR

I have said before that in a sense agriculture itself is a kind of warfare—against adverse weather conditions, lack of soil fertility, diseases, insects and all the other enemies of maximum production and utilization of farm products of many kinds. Agricultural research has long been mobilized, and must remain mobilized, in a campaign that will never end against these enemies.

But we have had to have a more intensive mobilization to meet the tremendous needs of to-day. More than two years ago, experiment station directors and staffs, seeing the problems ahead, started to scrutinize their station research projects carefully. In an effort to have funds, personnel and facilities available to tackle many new problems, certain of the regular projects which apparently would not make as immediate or direct contribution as some others to the war were laid by, so to speak, until after the war, or until circumstances indicated the need to resume or intensify work on them. The resources of the State agricultural experiment stations have been marshalled for the job of supplying facts to solve many of the problems involved in the record demands for food, feed and fiber occasioned by the war. Care has been taken, however, to prevent the loss of long-time experiments, such as soil fertility plots, and of valuable plant and animal material.

In the fiscal year 1942, Dr. Jardine, chief of the Office of Experiment Stations, tells me that there was an increase of 16 per cent. in the number of research projects undertaken by the States under Federal-grant funds compared with the average of the five preceding years, and that the regular research projects were modified where necessary to have them contribute more directly to the war effort. In 1943, there were over a thousand research undertakings by the States involving cooperation with bureaus of the Agricultural Research Administration and agencies of the War Food Administration. Many of these projects, of course, had been in progress before the war.

In the Federal Department of Agriculture in December, 1941, the Secretary of Agriculture grouped several agencies into an Agricultural Research Administration with the purpose of coordinating and centering research activities of the department upon war needs. To review briefly: The field covered by the Research Administration includes the following research bureaus—Animal Industry, Dairy Industry, Human Nutrition and Home Economics, Entomology and Plant Quarantine, Agricultural and Industrial Chemistry, and Plant Industry, Soils and Agricultural Engineering—the Beltsville Research Center, the Office of Experiment Stations and the four Regional Laboratories devoted to research on the industrial utilization of farm products and by-products, and nine Bankhead-Jones laboratories devoted to research on certain agricultural problems common to groups of States in the major agricultural regions.

By coordinating the work of those research agencies even more closely than in the past, it is possible to plan and carry out concerted attacks on certain problems and get important results more quickly than would have been possible without such close teamwork. Early in the war, we in the department also critically examined our whole list of projects, laid aside work that could be postponed if it did not bear immediately on war needs, reoriented other projects to meet wartime demands, and prepared to take on the many emergency projects that have been continually developing since the war began. In making these changes we, too, have been careful, of course, not to waste any stocks of valuable material or jeopardize long-time research programs. Ninety-two per cent. of current research activities in the Agricultural Research Administration are directly connected with the war.

The ability of this nation progressively to increase its production of food, feed and fiber during the past three years is due to a great extent to the large accumulation of data from past research and the all-out application of research agencies to the job of interpreting and applying accumulated facts and acquiring new facts which could be disseminated by extension agencies to the farmers, who were confronted with what looked to some an almost impossible task.

It was relatively easy for all of us to determine what increases of certain products were needed, but among other things, such as supplies of labor, farm machinery, fertilizer, etc., the accomplishment of the goals has involved greater efficiency in using soil resources; superior seed stocks of improved crop varieties; improved growing, harvesting, distribution and utilization practises; improved animal feeds and feeding, and reduction in losses from insect pests and diseases. In meeting the demands for more livestock, it was necessary to produce more feed, to make maximum use of pasture and roughages and to provide substitutes for some feedstuffs.

Vice-President Wallace emphasized the importance

of agricultural research in a statement he made recently: "It is only because of the extraordinary technological discoveries of the U. S. Department of Agriculture and the State experiment stations in soil management, crop breeding, and livestock feeding that we . . . have been able so far this year to ship food abroad at an annual rate of about 10 billion pounds." In other words, back of the ability to ship this great quantity of food, and at the same time feed our own people adequately, is the ability to produce food; and back of the ability to produce it are the intelligence and will of our farmers and the years of patient fact-finding of our scientists.

The emphasis and the concentration of investigators on special problems as well as the whole-hearted cooperation between State and Federal workers and those in other research and educational institutions have resulted in many contributions of decided value in the war. As perhaps never before, projects have been coordinated and the services of individuals with special technical knowledge have been used.

As examples illustrating how scientists have cooperated in attacking regional and national problems connected with the war, I might mention the nation-wide cooperative study of how best to conserve nutritive values of 69 different foods which is participated in by 46 experiment stations and the Department of Agriculture; and the cooperation of many State stations and the Department of Agriculture in determining where kok-saghyz (the Russian rubber-bearing dandelion) and various fiber and drug plants can be grown.

Many important agricultural problems during the past few years have been investigated by the nine Bankhead-Jones regional research laboratories. These laboratories were organized in cooperation with the State agricultural experiment stations and were located in different sections of the country. Valuable knowledge has already been obtained in the fields of vegetable breeding, salinity in irrigated soils, animal and poultry diseases, pasture improvement, soybean production, sheep and hog breeding and the interrelation of soils, plants and animal nutrition.

Similarly, the four regional laboratories at Albany, Calif., New Orleans, La., Philadelphia, Pa., and Peoria, Ill., organized to find new and industrial uses of farm products and by-products, have already made discoveries important to the war as well as to our domestic economy.

Thus, although faced with difficulties in retaining an adequate number of trained research workers and in maintaining essential facilities during the past two years, the experiment stations, the U. S. Department of Agriculture, universities and other research institutions have solved many new problems and have increased the volume of their services. A few examples will illustrate recent accomplishments:

(1) At the beginning of the war, we were dependent on foreign countries for supplies of certain drug, fiber and rubber goods obtained from plants. Now through the cooperation of the scientists at the State experiment stations, universities, research institutions, drug manufacturers, industrial research laboratories, farmers and the Federal Government, we have found ways of growing, harvesting and processing these crops. In some cases, our needs are wholly being met; in others, we are in position to meet most of the essential needs if it becomes necessary.

(2) Faced with a shortage of labor, the agricultural engineers cooperating with other scientists have originated new labor-saving machinery for the planting, production and harvesting of several crops and have modified other machinery and developed new practises for such purposes as refrigerated transportation.

(3) Faced with the necessity of conserving shipping space, scientists in many fields have cooperated in determining how to dehydrate, ship, store and reconstitute many food products such as meat, milk, vegetables, fruit and eggs without undue loss of palatability and nutritive quality.

(4) At the request of the armed forces, entomologists have developed new and original methods of freeing and protecting men from body lice, mosquitoes and other insects. In cooperation with other scientists, they have developed substitutes for some of the insecticides and fungicides formerly used in agricultural production and now scarce.

(5) Chemists, physiologists and other scientists have solved a host of specific problems such as developing more efficient methods of obtaining alcohol from wheat; preventing the deterioration of fabrics for domestic use and military purposes; finding ways to make soft, downy fluff out of chicken feathers to substitute for down from waterfowl for filling sleeping bags and pillows for the armed forces; making new plastics derived from wood and from crop residues; increasing the flow from pine trees of oleoresin, much needed by the armed forces; successfully transplanting trees and shrubs at different times of the year for camouflage purposes; and modifying sterility and increasing the milk flow of animals by the use of hormones.

(6) Home economists, among many other activities, have investigated and given advice on how to cook food on a large scale, under conditions such as those found in service camps, so as to achieve great savings of nutrients; have calculated the nutritive values of available and potential food supplies as a guide for production and rationing policies; have found ways to use alternate foods and fibers and distributed an immense amount of information on how to get the maximum use out of products no longer made in liberal quantities; and have designed clothes and uniforms for special purposes and conditions.

(7) Much work, in the aggregate, has been done on the problems of nutrition, particularly in relation to protein supplies for both human beings and livestock. With shortages of protein feeds, especially of animal origin, a

limiting factor in livestock production, physiologists have had to determine how little could be used and to what extent one source of protein could be substituted for another in rations. Chemists and others have worked on the problem of recovering as much valuable protein as possible from distillery by-products instead of having it go to waste; and, incidentally, a new method has been developed for making alcohol from wheat which may have possibilities for large-scale protein recovery. In the case of diets for human beings, one of the main problems has been to work out ways of using more protein directly from plant sources rather than have it converted first to meat in the animal organism. Work done with soybean, peanut and cottonseed products has shown the nutritional value of their proteins, and home economists have developed many recipes and formulas for the use of soybean products. In this connection, recent research on amino acids promises to give us a more accurate knowledge of protein nutrition than we have yet had.

During the war, too, plant breeders have carefully studied new materials of promise which were near the end of pre-distribution tests. Where certain ones possessed attributes which indicated they would reduce production risks, they have been increased for immediate farm use and distributed. The introductions have included cereals, fruits, vegetables, cotton, soybeans, sugarcane and other important crops.

I should like to discuss certain other contributions of value to the armed forces, but of course that can not be done now. Some day when all the contributions of science to the war can be told, they will make an extraordinary story.

THE VALUE OF FUNDAMENTAL RESEARCH

The few examples just given illustrate the originality, ability and cooperativeness of agricultural scientists. They show that agricultural research, both abstract and applied, carried on during peace times has been immensely useful in time of war. Naturally applied science must be stressed in all agricultural research carried on by public agencies. But the development of basic information and the discovery of principles upon which practise can be based make it possible to arrive at a more speedy, direct and satisfactory solution of problems. The whole progress of science and the application of its findings depends on filling in the gaps in our knowledge of the nature of things. There is a very definite limitation indeed to the extent of progress which can be made without a backlog of fundamental knowledge.

Hybrid corn, planted on approximately 50,000,000 acres this year, is a familiar example. We all know that the development of hybrid corn was preceded by a good deal of work which most people would consider purely theoretical genetics. Perhaps not all of it was essential to the practical breeding operations, but a good deal of it was. Waxy corn was a by-product of some of this work; it had no practical value at the time it was discovered but was carried along for its theoretical interest. Now it is of very great importance, along with waxy sorghum, as a source of a possible substitute for tapioca starch.

The work on the influence of day length on plant development and distribution is another case in point. Among many other things, an understanding of the photoperiodic requirements of different plants has affected agricultural production in widely different ways. It has made it possible, for example, to produce potato seed for breeding purposes under controlled conditions in large quantities, to determine the adaptability of many kinds of plants to widely separate areas and eliminate the practise of trying to grow them in regions to which they were not suited, and to control the blooming time of chrysanthemums and other florists' crops; and it has helped to make it possible for us to become independent of foreign sources of sugar-beet seed.

Another example is the seemingly abstract research on the effects of plant hormones on the physiological and anatomical responses of plants. This work has been applied to the prevention of early dropping of fruits, facilitating the rooting of plants for propagation and transplanting, wound healing, maintaining the dormancy of nursery stock, fruits and vegetables in storage, greatly increasing the percentage of fruit set on crops such as tomatoes, and increasing the size of some fruits. There have been many other applications, and a whole new chapter in man's control of plant development through chemical means is in the making.

An especially striking example of the importance of supporting fundamental research is found in the remarkable results now being obtained with penicillin in preventing or clearing up infections. All the funds that have been provided for many years to study the growth, reproduction, physiology, relationships and life histories of the many species of plants grouped under the general term "fungus" would be justified by this one discovery, even if all such work had not already been paid for very many times over by economic applications of the results of critical research. Because of the knowledge of investigators versed in the cultivation of fungi on a large scale, it will now be possible to produce large quantities of penicillin and save the lives of thousands of people.

These examples are singled out from among hundreds of outstanding contributions which have had their basis in fundamental research because they are of great current interest and because they bring home to us the direct connection between the accumulation of basic knowledge and its application in a highly practical and often dramatic way.

(To be concluded)