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DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

March 16, 1967

Dr. Donald Hornig
Director, Office of Science and Technology
Executive Office of the President
Washington, D. C.

Dear Don:

Pursuant to our discussions on March 14 relative to ideas for the Summit Meeting, the attached is submitted for your reaction. I have not cleared this within A.I.D. so please regard it as a "think piece", for your judgment as to whether it is worth following up.

Sincerely yours,

A. H. Moseman
Assistant Administrator for
Technical Cooperation and Research

630.11 Moseman, Albert H.
M898 [Agricultural development] Various papers.
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1.Innovations - Agriculture.2.Agricultural education.
3.Fish protein.4.Agro-industry.5.Food technology.
I.Research needed for technological knowledge.
II.Dimensions of agricu re in international
development.III.Agribus ss abroad.
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Applied Science and Technology for Increasing Food Production in Latin America

It is estimated that food and fiber imports into Latin America require expenditures of about $600 million per year and such needs are rising. About a third of the imports have been supplied in recent years through PL 480 and the foreign exchange drain has been about $400 million. The modernization of agriculture in Latin American countries is, therefore, a major factor not only in saving millions of dollars in scarce foreign exchange but also in building the essential base for economic and social development.

Population growth in some Latin American countries is the highest in the world with the population of Costa Rica, which is growing at the rate of 4.2 percent annually, expected to double within the next 16 years. It is estimated that Mexico's population of 40 million also will double in 20 years. Family planning programs are being established in a number of Latin American countries but the impact on birth rates will be slow and the solution to the food problem over the next two or three decades will be through increasing production of food crops.

The U. S. has been engaged in cooperation in agricultural development for a longer period in Latin America than in any other part of the world. Curiously, however, there has been little attention given to the application of science and technology for agricultural improvement. As stated by Professor T. W. Schultz of the University of Chicago in the Hearings before the House Subcommittee on Agricultural Appropriations in February 1966, "After two decades, starting with the Point IV programs when about

a third of the aid funds for Latin America were allocated to agricultural development, and large amounts since then, there is not a single first class agricultural research center in Latin America to show for it. Why? Latin American governments have not vetoed such research. The reasons are predominantly of our own making; namely, (1) crash programs, (2) the agricultural extension bias, and (3) selling agriculture short in economic development, especially after the Point IV period."

Production Potentials Through Applied Science and Technology

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production in India, Pakistan, and Turkey. In August of 1966, India imported 18,000 tons of seed of the Mexican wheats to accelerate her increased food grain production program. The Government of Pakistan, in cooperation with the Ford Foundation, is utilizing the Mexican wheats as the major new input in a program designed to double Pakistan's wheat production in the five year period ending in 1970. Progress during the past two years suggests that this goal may well be achieved. The Ministry of Agriculture in Turkey is extremely enthusiastic about the increased wheat production potential from the use of the Mexican wheats and is considering the import of up to 50 thousand tons of seed of these outstanding varieties. An A.I.D. agricultural review team has estimated that Turkey could increase her wheat production from around the current 300 million bushels to one billion bushels in the next five to ten years by the use of the higher yielding varieties, and improved fertilization and water management practices.

It is paradoxical that while these prominent nations of Asia that are confronted with serious food shortages are looking to Latin America for the solution to their food problems the Latin American countries themselves have not effectively utilized these same resources within the hemisphere.

Crop Improvement Resources in Latin America

In addition to the widely adapted "Mexican wheats", other improved wheat varieties are available also from the cooperative research programs in Colombia and Chile, thus furnishing breeding stocks or varieties suited for almost any region of the world.

Extensive collections of corn germ plasm are available at research centers in Mexico, Colombia, and Brazil. Mrs. Johnson and Secretary and Mrs. Rusk visited Chapingo, Mexico, on April 16, 1966 to observe the research program under way at the International Maize and Wheat Improvement Center, a corporation jointly supported by the Government of Mexico, the Rockefeller and Ford Foundations, and other organizations.

Collections of beans are available both at Chapingo and at the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica.

Latin America is the home of the potato and a nucleus of an "international research center" has been established at La Molina, Peru, through collaboration of North Carolina State University and the Rockefeller Foundation.

In addition to the regional or international centers for corn and wheat improvement at Chapingo, Mexico, for potatoes in Peru, and for bean research at Turrialba, the Ford and Rockefeller Foundations are considering development of a tropical agricultural research center to be located in Colombia. This would give attention to rice and other food and cash crops for tropical areas.

National research centers are coming into being in Mexico, Colombia, Peru, Chile, Brazil and elsewhere in Latin America, mostly through collaborative support from the Ford, Rockefeller and Kellogg Foundations, U. S. universities under A.I.D. contracts, the World Bank, and the Inter-American Development Bank.

Procedures for Strengthening Agricultural Science and Technology

The basic structure for international or hemisphere-wide agricultural research centers is coming into being and the national institutional systems

for agricultural science and technology that are evolving furnish patterns to facilitate the establishment of similar national programs in other Latin American nations. The concept of cooperative, hemisphere-wide research for improvement of wheat, corn, potatoes, and beans, has been well established through more than 15 years of research and training supported by the Rockefeller Foundation, and by A.I.D. and other organizations.

A Latin American Association of Plant and Soil Scientists has been organized and this professional society furnishes an excellent base for Latin American agriculturists to supply initiative in planning hemisphere-wide research projects for the improvement of the major food crops. The society has informal committees of working scientists concerned with improvement of corn, wheat, potatoes, and beans. The experienced staff of the Rockefeller Foundation at the International Maize and Wheat Improvement Center would be available for guidance, as would personnel from the U. S. universities and A.I.D. in selected countries.

The initial steps would be to establish joint working groups of Latin American and U. S. scientists to design the long range research programs -- of ten years or more -- to improve varieties, soil fertility and water management practices, and general production and harvesting procedures. The working groups also should develop schedules for training of personnel in an orderly fashion to meet the manpower requirements not only for technicians but also for top level professionals to furnish the conceptual leadership and direction for a sustained research program in each of the participating countries.

This is a program that would require relatively modest additional funding from the U. S. -- at a level of only 10 to 15 million dollars annually for research operations and training. The major input would be the

professional leadership and for scientific and organizational guidance, and the initiative to establish the respective working groups. The program should be started immediately because approximately five years will be required for the development of well organized and well staffed research and testing programs, with an additional five years needed for training of the qualified scientific leadership that should be established in the respective cooperating countries.

This program is a natural vehicle for multi-national or hemisphere-wide cooperation, and it furnishes full opportunity for "self-help" and "self-satisfaction" in national accomplishment as well as in regional cooperation. It would place the hemisphere in a position of world-wide leadership in research for or improvement of crops that are native to the region, such as corn and beans, to supplement the international recognition already achieved for wheat production.

President Johnson visited the International Rice Research Institute in the Philippines last fall and Mrs. Johnson visited the similar center for wheat and maize research at Chapingo so the President is in position to relate personally to this type of activity in presenting a proposal to the Summit Meeting.

A. H. Moseman
March 17, 1967

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Address by A. H. Moseman
Assistant Administrator for
Technical Cooperation and Research
Agency for International Development
Department of State

At

The Annual Meeting of the Chemurgic Council
Columbus, Ohio

September 22, 1965

A.I.D.
Reference Center
Room 1656 NS

It is a real pleasure to participate in your convention program this evening, to renew acquaintances with many professional colleagues, and to renew contact with the Chemurgic Council. It was almost ten years ago, in April 1956, that I was on your program to discuss "The Challenge to Find New Crops" for American agriculture.

On the basis of the strong reassurance from your President, Mr. Martin L. Corey, that your conference has a special interest in the technical cooperation and research activities of our foreign aid program, I made a special effort to join you tonight. Our foreign aid program has been blessed and bolstered by those who are fully appreciative of its national and international significance; damned and downgraded by those who question its merits, either on the basis of concept or operation; and is viewed with some uncertainty by the larger numbers of people who do not fully understand what is involved.

A CONTINUING FOREIGN AID PROGRAM

Perhaps it would be useful to review the genesis or evolution of U.S. foreign assistance as related to some of our national objectives.

-- The first U.S. venture in foreign aid was the Lend Lease Act of March 1941, to bolster resistance of the Allies to Axis powers.

-- One year later, in March 1942, the Institute of Latin American Affairs was established, to furnish the first U.S. help to develop the resources of our Latin American neighbors.

-- In 1943, we initiated large-scale assistance to the liberated countries, through UNRRA.

-- In May 1947, Congress authorized economic and military assistance to Greece and Turkey, to guard against a communist takeover in those countries.

-- In April 1948, the Economic Cooperation Act (Marshall Plan) created the first of the A.I.D. predecessor agencies.

-- Twelve months later the North Atlantic Treaty was signed, creating NATO, and in October 1949, Congress passed the Mutual Defense Assistance Act.

-- In June 1950, the Act for International Development (Point IV) created the Technical Cooperation Administration, which absorbed the activities of the IIAA. Also, the amendment of the China Aid Act of 1948 provided for assistance to less developed countries of the Far East.

-- In June 1951, the Marshall Plan was terminated and in October the Mutual Security Act united the U.S. military and economic programs under MSA.

-- In August 1953, the Foreign Operations Administration replaced MSA and absorbed TCA.

-- In June 1955, the International Cooperation Administration replaced FOA.

-- In August 1957, the Development Loan Fund was established. A year later it was given corporate status and took over part of ICA's activities.

-- In September 1961, the Act for International Development combined ICA, the DLF, and other U.S. assistance functions under A.I.D.

For the first time, in 1961, the many interrelated aspects of economic and technical assistance were brought together into a single agency.

The continuous changes in organization, in legislation and, at times, in focus or objective have created the impression that our foreign aid program is a temporary venture. Yet, nearly 25 years have passed since the United States embarked on the first cooperative assistance effort, in 1941. Since World War II about $40 billion of economic aid has gone to help the recovery of Western European

countries, and to improve levels of living in the countries of Asia, Africa, and Latin America. As stated by the Advisory Committee on Private Enterprise in Foreign Aid, under the leadership of Arthur K. Watson, Chairman of the IBM World Trade Corporation, in its report of July 1965, "By and large, foreign aid has achieved a great deal. Yet -- the programs seem to have presented an uninterrupted series of crises. In the annual Congressional reviews, the programs' many remarkable accomplishments often have seemed swamped by accounts of its shortcomings and failures."

The Committee further recognized that in the perspective of history, "both the time and the money will seem modest. Twenty years is hardly long enough for a single generation to grow out of a deprived and ignorant childhood. The $40 billion is less than one half of one percent of the wealth produced by the United States during this period."

As we look at the record of commitment of our government to foreign assistance, and as we view the present inequalities in well-being among the peoples of the world, we can be fairly certain that we will not put aside a job that is yet largely to be done.

WHY SHOULD AID CONDUCT RESEARCH?

Our time this evening will permit the discussion of only a few aspects of the A.I.D. program of technical cooperation and research.

There are undoubtedly many different concepts of technical assistance; but for our purposes this evening we shall consider the transmission of skills, resources and techniques which can accelerate human and economic development, as well as the creation and distribution of resources that are essential to the achievement of these goals.

A question that might well be asked, especially when we look at the long history of our foreign aid activities is, "why is it necessary or desirable to establish a research program in A.I.D. when we had no such specific research effort either within the Marshall Plan program or in the early years of the Point IV program?" It was not until 1961, about ten years after the Point IV program was initiated, that authorization was included in the Foreign Assistance Act to utilize certain funds for the development of essential and related research.

There are a number of reasons why our earlier foreign aid efforts progressed without a specific research input. The cooperating countries of Europe, and Japan, all had a rather highly developed base of science and technology upon which to rebuild their economies. They had the institutions or the infrastructure to accommodate rapid economic rehabilitation. The levels of literacy were high. Also, agricultural practices or materials from the U.S. were readily transferred to similar temperate zone growing conditions.

The less familiar economic, social, and biological environments of many of the countries of Asia, Africa and Latin America have presented new complex challenges and the transfer of U.S. technology and know-how has flowed less smoothly. The Watson Committee, in recognition of the desperate race between population growth and food production, emphasized that research for agricultural development "justifies the greatest attention of A.I.D.," but pointed out that "Our ignorance of what works and what does not is also evident in the fields other than agriculture. For example, we are unsure about the kind of public administration systems that might work in the varied circumstances of Latin America, Africa and Asia. We are uncertain about the type of educational techniques and educational curricula that might be most appropriate to the state of literacy and kind of society encountered in these areas. And, ironically enough, we are even unclear about the type of industrial technology which might be most appropriate to the little markets in underdeveloped industrial environments that are characteristic of the less developed world."

The Task Force on A.I.D. - University Relations chaired by Dr. John W. Gardner, then President of the Carnegie Corporation and recently named Secretary of the Department of Health, Education, and

Welfare, in 1964, also strongly endorsed the move to initiate an A.I.D. research program. In the view of that committee, "We still know all too little about the processes of modernization. We need research and lots of it, basic and applied, in the field and on the home campus. A.I.D. has a legitimate role, indispensable to the fulfillment of its larger purposes, in the development of new knowledge and the application of that knowledge to development assistance activities."

WHAT SHOULD AID RESEARCH?

If we take the judgment of the Watson Committee, A.I.D. should finance increased research imaginatively related to the agricultural, industrial, educational, and administrative needs of the less developed countries. A myriad of problems should be brought into sharper focus and subjected to precise study. There are, of course, divergent opinions about priorities and we are well aware of growing concern about water supplies, population growth, malnutrition, and others. For our immediate attention this evening, however, the population and food supply situation might well be in the forefront.

About one year ago, at the American Chemical Society meetings in Chicago, Dr. Raymond Ewell of the State University of New York at Buffalo predicted that if Asia, Africa and Latin America are not using quantities of fertilizer approaching 30 million tons by 1980, they almost certainly would be engulfed in widespread famine by that time. Dr. Ewell, though often quoted in the past 12 months, is not alone in voicing concern about this prospect. It just happens that he spoke when

there appeared to be a lull in the conversations on other important national and international issues -- and he was heard.

There is some tendency to look upon food production and population growth as a race between vehicles on a collision course, with a crash inevitable. We can expect an increasing impact but let's realize that the fenders already are touching. The food deficits in India and elsewhere are growing greater. Since 1960 the gap between annual food production increases and population growth has ranged from one percent per year, or more, in many countries of Africa and Asia, to the nearly ten percent per capita decline in Latin America since 1959.

PROSPECTS FOR MEETING FUTURE FOOD REQUIREMENTS

We know that food production can be increased substantially in the developing countries in the future through application of modern science and technology. This, however, will not be accomplished in a hurry and we face at least a decade or two of gradual change, under the best of conditions. The improved technology not only must be adapted, it also must be accepted and used by the large numbers of individual decision makers in traditional agricultural societies.

It will be essential, in the immediate future, to move food supplies from areas with high productive capacity to the deficit countries. The U.S. Food for Peace program shipped 18 million tons of food to 40

countries in 1964, including India, Pakistan, Korea, Algeria, Egypt, Turkey, Brazil, Chile, Peru, and many others. This volume is pressing the limits of available shipping capacity and the docking and transport facilities in some receiving countries. There are logistic limits to further expansion of such shipments.

It is significant that the Food for Peace shipments are regarded increasingly as a positive program to help the developing nations to build vigorous economies, and less and less as a "surplus disposal" problem. As stated by Secretary Freeman, "In a very real sense, the American farmer has become a farmer for the entire world. Last year we shipped to other countries the harvest of one out of every four acres of American cropland."

The magnitude of our food shipments abroad may be restricted in the future not only by problems of transport but also by our own national needs. We tend to think of the plight of other nations when we talk about the balance between food and people. Yet the Population Reference Bureau points out that in the U.S., the 195 million mark in population was reached this month (September) and at the present rate of growth we will top the 200 million mark by May of 1967. Our population is growing by about 7,200 each day and if continued at this rate, in just over 60 years we will have as many people as India has today -- approximately 460 million.

It is rather interesting to consider the increased crowding of our nation from the time of the birth of our fathers through the span of the life expectancy of our sons, during which the U.S. population will have grown from about 57 million (1885) to the 460 million estimated for the year 2,025. Fortunately, we can face the future with substantial confidence, not just because we have productive crop varities, fertilizers, pest control measures, and efficient farm machines, along with the credit, marketing, and other institutions that are essential, but more important, we have the research and education system capable of continuously resolving problems and of producing innovations to meet expanding needs.

I use the term "substantial confidence" in meeting our future needs because we cannot become too self-assured and reckless in allocating our agricultural resources. We have already achieved a high level of extraction of science and technology for agricultural output and we are handicapping future capacity by planting housing developments, shopping centers and gas stations in too many of our grain fields. We must, therefore, maintain the strength in our national programs of agricultural research that embody such excellent federal, state and private participation.

We can help to meet emergency food requirements of other countries during the immediate years ahead and we also should move

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vigorously in furnishing the fruits of our technology so that these short term needs can be met. Most important, however, is our assistance in building indigenous research and education institutions in cooperating countries, to insure local capability to meet future needs. This latter goal is important not only for those countries with food deficits today, but also for those temporarily able to meet their domestic requirements. They too must be in a position to meet the needs of future generations and cannot continue to borrow the science and technology, year by year, to keep pace with expanding requirements.

Projects patterned after the research that is most popular in the U.S. today, where much of our effort is devoted to exploring for new knowledge, have less relevance in countries where traditional agriculture must be upgraded abruptly. Greater emphasis must be placed on adaptive research, the reshaping of available information and materials to fit other environments or cultures. Increased attention must be given also to putting innovations to work since most of the developing nations do not have the automatic demand or pressure for new knowledge or practices that a highly industrialized society, such as the U.S., exerts upon our research laboratories. There is a need to design innovations that are suitable and acceptable to societies reluctant to move away from practices they feel are tried, proved,

and involve a minimum of risk. Problem-oriented research, directed to the needs of developing countries is not second class research and, as stated by Dr. Donald S. Hornig, Science Advisor to the President, "Applied research and technological development often require more ingenuity, imagination and creativity than basic research."

We know that it is possible to double or triple yields of the major food crops of a developing nation through adaptive research that is well conceived, vigorously pursued, and carried on a sustained basis. We cannot simply shuffle and rearrange present inadequate materials and practices. Research to improve crop varieties, soil fertility, water management, pest control and other practices must furnish the new inputs for farmers if they are to increase their harvests. The cooperative wheat improvement project of the Government of Mexico and the Rockefeller Foundation, which raised national average yields from about 11 bushels per acre in 1943 to more than 39 bushels in 1964 demonstrates what can be done. This experience must be replicated in other countries.

FAMILY PLANNING

There is a growing world-wide cognizance of the need to achieve a better balance between population growth and food production potentials. The slowdown in population growth will not be easy to achieve. As pointed out by the Population Reference Bureau, once a

contracts for technical assistance work in 76 countries. U.S. universities

country's population passes the 100 million mark, even a moderate fertility rate produces a sizeable numerical increase. The population of India, for example, is increasing by 5 million every 150 days. If India suddenly cut both her birth rate and death rate in half, making them roughly equal to the rates in the U.S. (21.2 births and 9.4 deaths per one thousand), her population would still increase at well over 5 million a year. In Canada, on the other hand, where the population is less than 20 million, it would take over 10 years at the current rate of growth to reach a total of 25 million.

The U.S. Government position with respect to family planning has been modified within the past few years. Although it is fully recognized that family planning decisions must be the choice of the individual, it is considered reasonable to broaden the base of knowledge from which choices might be made. Many public as well as private institutions carrying on research on population problems have shifted from strict demographic studies to the more relevant research on reproductive physiology and on practices that might be utilized to plan family size.

A.I.D. - UNIVERSITY - INDUSTRY RELATIONS

American colleges, universities, business and professional firms, and service organizations hold more than $400 million in A.I.D. contracts for technical assistance work in 76 countries. U.S. universities

have participated in foreign assistance activities for more than a decade and additional university involvement is encouraged. A special assistant is attached to the Office of Technical Cooperation and Research to guide this relationship.

The increased cooperation of U.S. industry in economic development activities also is highly desirable. There is need for managerial skills in production and marketing, and for the development of the government - industry - farm production relationship that is characteristic of the U.S. and Western Countries. During the 1950s, U.S. industry gave attention primarily to domestic and European markets, with little interest in investment in other areas of the world. As late as 1961, no U.S. fertilizer company had undertaken fertilizer production in a less developed country. This situation is changing and today U.S. companies are operating, building, or have in advanced stages of planning, at least 21 fertilizer plants in 19 countries.

A.I.D. is taking steps to develop background information that will be useful in encouraging additional industry participation in technical and economic development efforts. A study is underway, conducted by the TVA, of the operations and the projections for investment and work of the fertilizer and pesticide industry in the less developed countries. A.I.D. is planning to initiate research on the marketing and distribution of fertilizers in other countries. A preliminary survey

of potential interest of the U.S. seed industry in operations abroad also is underway.

A new cooperative venture of A.I.D. that is just getting started is the establishment of an Institute for Industrial Technology and Applied Science in Korea. The proposal for this Institute emerged from the discussions between President Johnson and President Park of Korea during their meetings last May 17. A field survey in July, conducted by a small team of specialists under the leadership of Dr. Donald S. Hornig, the Science Advisor to the President, resulted in the recommendation that further steps be taken, in cooperation with Korean scientific and government leaders, to explore specific plans for the Institute. A five-man team of scientists from the Battelle Memorial Institute departed for Korea this week to develop recommendations on the scope of work, pattern of organization, and understandings relative to financing. The proposed Institute is expected to give attention to the development and maintenance of standards and to investigations to eliminate problems that confront existing industries in Korea. The most important function of the Institute, however, would be to conduct the type of basic and background research that would provide a continuous flow of scientific knowledge and innovations essential for Korean industries to grow and develop on their own initiative. The proposed Institute would be designed to furnish a

pattern for the guidance of industrial science and technology in other developing countries in the Far East region.

In closing, I should point out that in addition to agriculture and rural development; health, nutrition and population; and industrial development, we are alert to research needs in education, transport and communications, public administration, and other fields. We are anxious to draw more heavily on the experience of the universities and private industry - to couple such resources with the growing abundance of knowledge gained by A.I.D. personnel who have confronted a wide variety of problems in economic development in many countries for more than two decades. There is need for constant exchange of views to insure better mutual understandings that will enable us effectively to share the challenging opportunities - as well as the responsibilities - in achieving the economic development objectives of our A.I.D. program.

DIMENSIONS OF AGRICULTURE IN INTERNATIONAL DEVELOPMENT

In his report to the United Nations early last month, FAO Director-General B. R. Sen stated that it will be necessary to increase food production fourfold on a world-wide basis in the next 35 years, or by the end of this century, to meet the needs of the world's rapidly growing population. This is only one of many similar recent assessments of the magnitude of the task confronting the world's agriculturists.

Regardless of how we assemble the data or draw the curves depicting population growth and potential food supplies, it is abundantly clear that prompt and vigorous action must be taken if we are to avoid what Dr. Sen has termed "a disaster of unprecedented magnitude." The curtailment of population growth is essential for the longer term but increased food production is the only solution to the hunger problem of today and tomorrow.

To meet rapidly expanding world-wide food needs, we might consider three stages of a long-range program. The first is the increased output of food supplies in areas with current or potential surplus productive capacity, for shipment to deficit areas. A second is the prompt acceleration of research in developing countries to adapt scientific and technological advances from countries with progressive agriculture. (This is adaptive research, not "extension".) Finally,

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the Annual Meeting of the Association of Universities and Land-Grant Colleges, Minneapolis, Minnesota.

November 15, 1965

is the immediate action to speed up the establishment of indigenous research and education institutions so that developing countries will have the technological base to achieve the sustained growth in food production required to double and re-double yields over the next three to four decades.

THE TRANSFER OF ABUNDANCE

We are already well along in stage one, in moving food supplies from the United States and other countries with excess production to the deficit nations. In 1964, the U.S. Food for Peace program shipped 18 million tons of food to 110 countries, including India, Pakistan, Korea, Algeria, Egypt, Turkey, Brazil, Chile, Peru, and many others. Approximately 25 percent of the harvest of American crop land last year went abroad. Our Food for Peace shipments are regarded increasingly as a necessary program to help developing nations build vigorous economies. When we recognize that only a few regions of the world, including the United States and Canada, Western Europe, and Oceania, are continuing to achieve food production at a level that surpasses their population growth, the need for a positive approach in the use of food resources to assist developing countries in wide expanses of Asia, Latin America, and Africa is readily apparent.

THE ADAPTATION OF MODERN SCIENCE AND TECHNOLOGY

Research for the adaptation and use, in traditional agricultural societies, of the science and technology available from agriculturally

advanced nations should be initiated or accelerated immediately. We have learned much about international cooperation in agricultural development since 1942, when the Institute of Latin American Affairs was established, through the Marshall Plan, and subsequent technical assistance experience. The transfer of materials and techniques from the United States into Western Europe and Japan, with their similar industrial and technological bases and with their similar temperate zone environments, led some to believe that, similarly, we could transfer U.S. agricultural know-how throughout the world. The first decade of the Point IV program, from 1951, when we shifted our focus to the semi-tropical and tropical environments of Asia and Latin America, and later to Africa, has made it

During the past two decades, a number of well-planned cooperative research projects in sub-tropical or tropical areas have provided a resource base of materials and information that is now available for adaptation and use in other similar regions. We no longer are so heavily dependent upon the advanced agricultural technology from temperate zone areas.

Wheat Improvement

Outstanding progress has been made in improving the production potential of wheat, the staple food which provides approximately 20 percent of man's caloric requirements. The cooperative research initiated in 1943 in Mexico, by the Ministry of Agriculture of that country and the Rockefeller Foundation, has produced varieties with disease resistance, strength of straw, the capability to utilize high levels of nitrogen fertilizers, and other characteristics that combine to increase yields by four or fivefold the previous averages. Acre yields in Mexico have increased from about 11 bushels per acre in 1939 to more than 39 bushels in 1964, and a country which had been importing approximately half of its wheat needs is now in a position to share its abundance with other developing nations.

Wheat varieties developed in Mexico are well adapted in other countries in South America, in some parts of Africa, in the Near and Middle East, and in Pakistan and India. Some of these varieties have genes that condition a non-photosensitive characteristic so they will mature within a

given number of days irrespective of the day-length conditions. This characteristic makes it possible to move these varieties over a wide range of latitudes, extending from the equator to approximately 45 degrees north or south. The job of breeding and selection to incorporate special characteristics needed for various localized environments can be accelerated under semi-tropical conditions where two or even three crops can be grown each year. It should be possible with these improved basic plant stocks to develop wheat varieties adapted for almost any region in the world within a period of four to five years.

Rice Improvement

In the improvement of rice, which also furnishes approximately 20 percent of man's caloric food needs, we find a similar resource base rapidly coming into being at the International Rice Research Institute at Los Banos in the Philippines. This outstanding research center, established as a cooperative effort between the Government of the Philippines, the Ford Foundation and the Rockefeller Foundation, has been in operation only a few years. The concentrated multi-disciplinary research program already has furnished a number of outstanding contributions in identifying productive varieties and in determining effective means for disease and pest control.

The world collection of approximately 10,000 varieties and strains of rice is being tested under a wide range of environments and a number of outstanding selections, capable of producing many times the average of

1,200 to 1,400 pounds of grain per acre common in the rice bowl countries, have been identified. Some of these varieties also are non-photosensitive so will mature in about 100 days under varying conditions of day-length, permitting the growing of two and possibly three crops in a given year. This multiple-cropping will require improved disease- and pest-control practices but continuing progress in the use of chemicals or biological control techniques should provide solutions for these problems.

Corn Improvement

An excellent reservoir of corn germ plasm has been collected in Latin America and approximately 12,000 varieties or lines are maintained in Mexico, Colombia, and Brazil. Improved hybrids and synthetic varieties have been bred and selected for Mexico, Central America, and South America. Cooperative research for corn improvement has been under way in a number of countries in Asia, including Thailand, India, Pakistan, and the Philippines, as well as in Africa, for more than 10 years.

The efficiency and rapidity of progress in modern corn improvement was demonstrated in the cooperative work in India initiated in 1957. At the end of four years improved, adapted hybrids, capable of producing 50 to 100 percent more yield than the native varieties were available for all of the principal corn growing regions of the country, including the highlands of the Himalayas, the Gangetic Plain,

and the South Indian peninsula. This was possible largely because of the knowledge and materials available from the earlier Latin American research programs.

The potential for increasing corn yields substantially is great in many countries of Africa, in Asia, and the Far East. This will require, however, the establishment of well organized research programs within the selected countries where this crop is or may become important.

Similar progress, although with results at a somewhat less advanced stage, can be reported with the improvement of sorghums and millets, and with the grain legume crops that are so important as a protein source in the diets of many people in Asia and Africa.

Fertilizers and Pest Control Chemicals

In addition to improved varieties of the important food crops, capable of many-fold increases in production if properly fertilized and grown with effective pest and disease control measures, we must have in the developing countries adequate supplies of plant nutrients and pest control materials. There has been a growing awareness of this and since 1961 there has been a substantial expansion in the plans for and construction of fertilizer and chemical plants in many of the developing countries. There is, therefore, greater availability of the essential biological inputs for the increase of food crop production in food-deficit nations. Rapid progress can be made in many of these countries if they establish, on a scale required for the task, research and development operations that will insure the most effective use of these resources.

BUILDING INDIGENOUS INSTITUTIONS

One feature of the population growth and food production projections that is apparently not well appreciated is the dynamic force and magnitude of the problems involved. Today's adequacies are meaningless, as are the temporary remedies furnished by imports of food grains, when populations are growing at the rate of two to three percent annually. If nations are to produce continuously increasing food supplies, they must have the indigenous technological capacity to meet these expanding requirements.

In only a few areas of the world can new land resources furnish the additional production needed. India, for example, will be able to add only 0.2 percent to its arable lands annually in the foreseeable future. In such countries, increased reliance must be placed upon science and technology to extract the maximum output from the land and water resources now available. On the basis of experience in the U.S., where we have doubled the per acre yields of many crops within two decades, we know it is perfectly feasible to achieve similar benefits from science and technology in the developing countries.

We have done rather poorly, however, in the agricultural development aspect of our technical assistance programs and, as pointed out by Dr. T. W. Schultz, "Although our Government has been actively engaged in technical assistance in agriculture throughout Latin America for two decades,

the sad truth is that not a single first class agricultural research center has been developed as a consequence of these activities." Food output per capita in Latin America is actually 16 percent under the mid-1930 levels and the development of effective indigenous centers for agricultural science and technology remains as the most critical challenge in our technical assistance efforts.

The Research and Education Base for U.S. Agriculture

The lack of progress in establishing effective organizational basis for agricultural development in the developing countries during the past two decades stems in part from our failure to benefit from the experience in the United States in achieving the world's most abundant and efficient agriculture. We continue to stress the transfer of U.S. "know-how", through extension-oriented programs, even though such transfer from foreign lands was found inadequate for our own agricultural and rural development more than a century ago. We continue to suggest that we build single, or a few, centers of educational excellence in the developing countries even though such excellence in "the red-brick universities" of our first few centuries did not suffice for U.S. development needs. We tend to place excessive confidence in single large centers of research excellence even though we would readily reject the notion that a Beltsville Research Center alone could provide the essential flow of innovations for U.S. agriculture. We are reluctant

to encourage developing countries to invest in more than a few institutions for agricultural research and education, failing to recall that when the Morrill Act was passed in 1862, our per capita income or gross national product was only a fraction of what it is today.

As we analyze the cooperative agricultural development efforts of the past two decades it is apparent that we have not really focused on the combined essential components of an agricultural research and education system but have supported only a few segments that are at best poorly coordinated and integrated into national programs. In summary, we have not supplied the same imaginative and forceful guidance that led to the passage of the Morrill Act, to the legislation establishing the U.S. Department of Agriculture in 1862, and to the subsequent actions that built our research establishment. On the basis of our experience we should not expect bargain basement short-cuts to work miracles in upgrading traditional agricultural societies. Because of their limited land resource alternative, it would seem essential for the developing countries to invest in the number and type of institutions required to furnish rapid and sustained improvements in their agriculture.

The needs of today's developing nations are very similar to those of the U.S. in 1862 and in helping to plan the indigenous institutional bases in these countries, we should keep in mind not necessarily the form but the functions of the organizations that guided U.S. agriculture.

President Elmer Ellis of the University of Missouri, in addressing the Rural Development Conference in Washington in July 1964, suggested that in 1962 we did not celebrate a "century of service" by the land-grant colleges and universities, but rather we celebrated a century of their existence. Following the passage of the Morrill Act in 1862, about 25 years were required to realize that a research component should be added to the educational institutions. This was done through the passage of the Hatch Act in 1887. Approximately another quarter century passed before action was taken to develop a system for getting the results of research into hands of farmers through passage of the Smith-Lever Act in 1914. It was only after these functions of education, research and extension were combined and coordinated that the land-grant colleges made their real impact on American agriculture, with the effects becoming increasingly evident during the 1930s and subsequent years.

The 68 land-grant colleges that finally emerged formed a system of research, education and extension in which nearly all of the component institutions played important roles. It has been suggested that perhaps only five or six were major contributors to our agricultural and rural development. This may be true for some isolated function such as graduate level education. If, however, we consider the diverse soil and climatic environments of this country, it is doubtful whether Penn State University could serve the needs of Texas; whether the Texas A&M system could serve

the development requirements of Washington and Oregon; or whether Oregon State University could serve the needs of the Great Plains States. A major strength of our land-grant colleges has been their full coverage in serving diverse needs over a wide geographic area.

Progress in agricultural and rural development of a nation is of interest not only to local or state political entities but also is of major concern to national governments. We are fully aware of the prominent role played by our Federal Government in the development of American agriculture through the introduction and exchange of plant and animal materials and the support of experimentation prior to, as well as after, the establishment of the Department of Agriculture in 1862. The research leadership and the full cooperative partnership of the USDA with the state experiment stations in resolving a continuing series of inhibiting factors in agriculture is well recognized. The ability to apply promptly the research resources of the U.S.D.A., through its own field stations and the cooperating state stations, has given us a quick problem-solving or applied research force for agricultural development not matched elsewhere in the world.

Dr. H. K. Hayes, Professor Emeritus of the University of Minnesota, who made major contributions to the development of hybrid corn in the United States, has pointed out that the real take off in the exploitation of the hybrid phenomenon for corn production in this country stems from the establishment in 1923 of the Cooperative State-Federal

Research program under the leadership of the late Dr. F. B. Richey. We have many additional similar examples of effective advances in American agriculture achieved through the combined efforts of the U.S.D.A. and State Experiment Stations.

The new and important partners in American agricultural development in the past 25 years are the wide variety of industries associated with agriculture, concerned with production of farm machines, chemicals, and other materials for production, and with the processing and marketing of agricultural products. Many of these organizations have engaged in research but their greatest impact has been in channeling improved materials and techniques into practice.

The Institutional Base to Transform Traditional Agriculture

The review of components of our own agricultural establishment brings into focus some elements we might emphasize in cooperative institution building efforts in developing nations. We should encourage the development of research and education centers in sufficient numbers and so located as to meet the needs of diverse climatic and soils environments. We should recognize the need for strong national programs of research, with inter-disciplinary attention to improvement of crop and livestock production, and with such research laced through the appropriate state or regional research and education centers. This would furnish the institutional base for the problem oriented research and for the

college level education that might best be supported through the government or public sector. Graduate level education similarly might best be handled through the public sector, concentrated at only a few of the research-education centers where outstanding staff competence and laboratory facilities could be provided.

The segment of the U.S. experience in agricultural development that is worthy of special scrutiny is the field of extension. Many of the developing countries already have some type of farm advisory service, through commodity organizations or within Ministries of Agriculture. Judging from experience in a number of these countries, however, it is questionable whether real changes in traditional agricultural practice will be achieved through the normal public sector or government channels. There is an apparent need for the type of initiative and convincing forcefullness that has been furnished under our own conditions by the "enterprise" of private industry. We should, therefore, explore fully the role of private organizations in the production and distribution of improved crop varieties, and of fertilizer and pest control materials, together with the advice on the proper use of such new inputs.

Promising Opportunities

We can identify a number of situations where some elements of the basic institutional structure for agricultural research, education and extension have been established and where the major need is for strengthening, or adding the deficient components. In Latin America, Mexico is perhaps farthest along in developing a coordinated, nationwide

research system and with the graduate and post graduate schools at Chapingo supplemented by a number of schools of agriculture throughout the country that are growing in competence. Plans are well along for a coordinated center for research, education and extension at Chapingo. Additional attention should be given to linking the research and extension functions and to a closer association of these activities, especially research, with the schools of agriculture.

In Colombia, plans for the establishment of an Institute of Agriculture with headquarters for the national research, education, and extension programs at Tibaitata near Bogota, and with research and education centers at the schools of agronomy at Palmira, Medellin, and elsewhere in the country, furnish another exciting opportunity to install a national system for agricultural development. Further attention should be given to the extension program, with special consideration to the linkage of research through extension specialists with the numerous federations or organizations concerned with coffee, cotton and other commodity production and marketing operations.

The agricultural university development program in India, initiated in 1955 by the U.S. Operations Mission, provides the sound nucleus of an effective research - educational base for the various climatic zones in that country. The research program conducted cooperatively by the Rockefeller Foundation and the central government of India, that is tied closely to the evolving agricultural universities, has effectively

established the concept, as well as the practice, of central and state government cooperation in agricultural research and education. The Post Graduate School at the Indian Agricultural Research Institute, inaugurated in 1958, is a going concern, with 400 students in residence as candidates for the M.Sc. and Ph.D. degrees. This total program for research and education should be materially strengthened and greater attention should be given to the extension function in which the participation of the private sector in seed increase and distribution, and in fertilizer and pesticide production and marketing, might very well become the most effective force in getting improved materials and practices used by Indian farmers.

Similar opportunities for developing well integrated national systems for agricultural science and technology are emerging in other countries, including Peru, Brazil, Nigeria, and the Philippines.

Personnel Resources

The effective exploitation of the new genetic resources for improvement of the principal food grains, and for the development of national institutional bases in selected countries will require a substantial increase in qualified scientists and educators from the U.S. to guide these cooperative activities. Such guidance cannot be furnished on a short time or intermittent basis. It requires individuals who are dedicated to this challenge as their first order of business and who are willing to

spend at least five years in continuous association with their counterpart colleagues in organizing and establishing the given research programs and institutions.

In recent discussions with land-grant college deans of agriculture, it has been pointed out that in many agricultural colleges in the United States there are from 10 to 40 vacancies in the regular research and teaching faculties. A similar deficiency exists within the U.S. Department of Agriculture where personnel limitations preclude participation in research projects of high mutual benefit to the U.S. and to the respective developing country. Appropriate steps must be taken to strengthen the technical staff resources of our land-grant universities and federal agencies if they are to assist in the long term institution-building job that is so essential in meeting world food production needs.

More attention should be given to the number of personnel assigned to institutional development projects. The optimum number will, of course, vary with the size and complexity of a given operation. For projects which involve the development of inter-disciplinary research in crop or livestock improvement, with an integrated education program, and a reasonable number of extension specialists, it is doubtful whether less than ten qualified staff members would make the desired impact. The optimum number might be nearer the 20 to 25 that have been associated with the

cooperative programs in Mexico, Colombia, and the Philippines that have produced measurable success in recent years.

The more active participation of the land-grant universities in agricultural and rural development programs of the food deficit nations might well require a new order of commitment on the part of the universities and their governing boards. A number of universities have established a position of Dean of International Programs. This has been helpful in establishing points of contact for cooperative activities but there appears to be uncertainty in some cases as to the willingness of the institution to support such Deans or offices, as evidenced by the difficulty they have in assembling multi-disciplinary teams of scientists from the university faculties to carry out technical assistance projects.

It would be desirable to consider the establishment of special "institutes" or "faculties" for international service, to focus the same degree of concerted attention on this activity as is now given to the work of other colleges or faculties in the university. This would foster the staff competence required for problems that are as exacting in their requirements as are those of regular departments of the university. A few of the land-grant institutions have initiated such special faculties in recent years.

Our inability to make long range commitments for our technical assistance efforts is a handicap to decision-making and program planning, not only within the A.I.D. but also on the part of other U.S. organizations

that are essential partners in these activities. This is recognized increasingly as we gain experience in research and education programs abroad. If we are to realize the potential of modern science and technology in increasing world food supplies, it will be necessary to design cooperative programs of the scope, magnitude and continuity that will have a reasonable assurance of succeeding. Hunger, termed by FAO's Director-General B. R. Sen as "the biggest human problem of the century" is a relentless, growing force. We must meet it with an equally relentless, sustained effort that combines the best experiences our scientific community can muster.

#3

AGRIBUSINESS ABROAD

by

ALBERT H. MOSEMAN

FOUNDATION FOR AMERICAN AGRICULTURE

INTRODUCTION

Dr. Albert H. Moseman is uniquely qualified to discuss the process of economic development in underdeveloped nations. For many years he has occupied a ringside seat at its very nerve center.

Reared and educated in Nebraska, Dr. Moseman graduated from the University of Nebraska in 1938 and gained a Master's degree there in 1940. His Ph.D. came from the University of Minnesota in 1944.

The next dozen years were with the Agricultural Research Service of the USDA in Washington where he served as Chief of the Bureau of Plant Industry, 1951-53, and then from 1953 to 1956 as Director of Crops Research. His service in that important post was distinguished.

He joined the Rockefeller Foundation in New York in 1956, as Associate Director for Agriculture. He soon became Director for Agricultural Sciences, where he was in charge of its worldwide agricultural program. He traveled the entire world and supervised many millions of dollars worth of agricultural research, educational, and development projects.

In 1965 Dr. Moseman again answered the call to public service, and returned to Washington as AID Assistant Administrator for Technical Cooperation and Research. In this post, Dr. Moseman is responsible for a very important sector indeed of our total effort to promote economic development in the underprivileged areas of the world.

Because of his broad experience in research and his several years with one of our great private foundations, Dr. Moseman understands perhaps better than the typical career civil servant the unique role that American agribusiness can and must play in our global development programs. The Foundation for American Agriculture considers it a real privilege to be allowed to publish the speech he made at its Board of Directors meeting in Chicago on December 1, 1965.

Earl L. Butz

NOTE: Dr. Butz is Dean of Agriculture at Purdue University. He is a member of the Board of Directors of the Foundation for American Agriculture and is Vice Chairman of its Program Committee. He was Assistant Secretary of Agriculture for several years during the Eisenhower Administration and serves on the Board of Directors of several large agribusiness corporations.—C.D.B.

AGRIBUSINESS ABROAD

by

Albert H. Moseman

Agency for International Development

When Dean Earl Butz extended the invitation to participate in this conference, he suggested the topic, "What Special Problems for American Agribusiness are Involved in Economic Development Abroad." In reviewing some of the uncertainties that might confront agribusiness in foreign operations, it is relatively simple to identify such factors as the percentage of foreign investment that might be permitted, and questions of tax exemption, pricing policies, etc. Problems with respect to credit, storage facilities, processing, distribution, marketing, transportation, and the availability of educational systems to supply technical and management competence, may confront private companies in various degrees and various combinations in the different host countries. Land reforms, including the consolidation of small, scattered holdings, are important in most primitive agricultural societies.

Although the foregoing and other similar factors are important they may well be secondary because *we cannot consider effectively the problems of the industries related to agriculture in the absence of a truly commercial agriculture*, the situation that persists in most of the food-deficit nations. Unless the man on the land is prepared to invest in the materials and production inputs supplied by industry, to increase his output sufficiently to support stable processing and marketing systems, we cannot close the circuit on a "business agriculture." The farm economy—the economic viability of the people on the land—is so inter-meshed into the total economy of production, processing and marketing that it cannot be ignored if we expect to build effective industries related to agriculture.

More Food, More People—Who Decides?

In efforts to resolve the dual, and interrelated, problems of rapid population growth and lagging food supplies, *we must give more attention to the prime decision makers.* The choice for size of family will be made by the individuals directly involved. Cooperative international activities in the field of family planning are designed primarily to furnish information and guidance to permit those choices to be meaningful, and to provide alternatives.

On the food supply side, similarly, *the decision to adopt innovations to modernize agriculture, with investments in improved seed, fertilizers, pesticides, and machines, or to continue traditional practices, rests within the individual farmer.* If world food supplies are to be increased fourfold in the next 35 years, the target set by FAO's Director-General B. R. Sen in his report to the United Nations in October, 1965, it will be essential to have farmers adopt not only one set of improvements but

a continuing series of higher yielding innovations that will achieve the doubling, trebling, and eventually, the fourfold increase in food production by the end of the century.

In the United States, with our large scale commercial operations, we can adjust output fairly promptly. The decision of one average U.S. farmer will change the production of about 350 acres. In many traditional agricultural societies, with small land holdings, it may be necessary to convince as many as 70 farmers to improve their practices to influence production on the same total acreage.

The problem of infusing innovations into traditional agricultural societies with small, scattered land holdings remains to be resolved. Mexico's wheat farmers, with substantial acreages in the irrigated areas of Northwest Mexico, with dependable yields from improved varieties, fertilizer applications and water management practices that are well tested, have shifted to the new materials and methods most promptly. On the other hand, it has been much more difficult to achieve similar progress in Mexico in the adoption of new corn hybrids and production practices. Although total corn production for the country has increased over the past decade, it has resulted in substantial part from added acreage.

Mexican Corn Yields Are Low

The corn yields per acre in Mexico, at about 15.5 bushels in recent years, are still among the lowest of the corn growing nations of the world, far under the U.S. average of approximately 65.0 bushels. The same difficulty in gaining acceptance or adoption of agricultural innovations is encountered in India, where high yielding corn hybrids suited to all major corn growing regions of the country have been available since 1961. By 1965, however, about only 8 percent of India's corn acreage was planted to these improved materials. When we realize that it took about 20 years to gain broad acceptance of hybrid corn in the United States—during a period of favorable markets and high farm income—we can appreciate the formidable task of bringing about changes on the land where small farms and subsistence practices prevail.

The Advisory Committee on Private Enterprise in Foreign Aid, chaired by Arthur K. Watson, Chairman of the IBM World Trade Corporation, in identifying factors that restrict operations abroad, stated, "Obviously, if business is to augment vastly its investments in the developing countries the odds must change—there must be less risk of loss and greater prospect of profit." This, of course, was only one of a number of the recognized restraints on new ventures into developing economies.

The risk that confronts agricultural business abroad, in a traditional and primitive agricultural society, is a problem that is fully shared by the individual farmer in that society. If we are to help guard against loss those companies that supply the essential inputs to increase production on the land, then we must give attention also

to effective risk guarantees for those who invest in the essential off-farm inputs to bring about a commercialized agriculture.

The farmer in a subsistence agriculture will probably demand innovations that will increase yields by 50 percent or more on a sustained basis. He is accustomed to wide fluctuations in yields resulting from favorable or unfavorable weather. Sustained increases in productivity can be achieved only by the inputs purchased from off the farm and they must be as risk free and certain of producing added yields year after year as it is possible to make them.

Uncertainties Are Minimized

The most certain *protection for the innovating farmer can be achieved only through intensive research and testing programs in the specific cropping environments, over sufficient periods of time to insure dependability of the new materials and practices.* The American farmer has been served in this manner for many decades by the experiment stations of our land-grant colleges with their extensive and well located branch stations within each State, supplemented by the widespread network of federal field stations. The research-test demonstrations in local communities, conducted by the wide range of private industries related to U.S. agriculture are significant forces in bringing about continuing improvements in our farm production.

The flow of new technology into and through the U.S. agricultural industry is steady, continuing, and systematized with problem identity and problem resolution almost automated by the many participants in our commercial agricultural system. We realize that the adequacy of our farm technology may extend for only a few months. The farmer in Northeast Nebraska who lost a large portion of his sorghum crop in 1965 because of a weak-neck condition of the maturing plants, caused by a disease accelerated by heavy rains a month before harvest time will expect, and will have, a variety for 1966 that will resist this hazard.

Those conversant with the highly interdependent relationships of the farmer, scientist, and industry in U.S. agriculture are fully aware that food deficit nations must develop a similar base of technology if the farmer and the related industries are to be served. As we survey the prospects for take-off in expanding food production in most of the developing nations, we find almost everywhere that we have yet to build the scientific and technological launching pads.

In only a few countries of Latin America, Asia and Africa do we have prospects of developing, within the next five years, even the research component or base for evolving technology. It will not be possible to build the complete infrastructure or integrated system of institutions that serve our commercialized agriculture. In view of financial and human resource limitations, both here and abroad, it is essential, therefore, that we isolate the most relevant components in establishing agricultural technology in food deficit nations.

Our experience in technical assistance in agriculture over the past 20 years, and especially during the past decade, has made it abundantly clear that we cannot expect any real impact from transplanting bits and pieces of a highly developed system of agricultural research, education and extension from the United States into traditional agricultural societies. On the other hand, we are fully aware that emphasis on extension, community development, modifications in land tenure or the economic structure, and other similar efforts to rearrange existing resources have not, by themselves, brought about sustained growth in agricultural productivity.

There has been increased emphasis in recent years, in planning agricultural research facilities in the United States, and also in some of the developing nations, on the larger regional, national, or international laboratories and field stations. These facilities, with scientists from the several fields or disciplines, provide for simultaneous study of many factors that combine to increase, or inhibit, yields.

Many Roles Played by Research

In the United States, the large regional research centers are well suited for a farm clientele that demands innovations and seeks them out. In a traditional agricultural society they also play a significant, but different, role.

Through well planned food crop improvement research programs under tropical conditions of Latin America and Asia, from centers such as the International Rice Research Institute in the Philippines, and the International Corn and Wheat Improvement Research Center in Mexico, we are developing techniques and producing materials that will greatly accelerate adaptive research for agricultural environments in almost any part of the world. It should be possible today, for example, to develop higher yielding varieties of all of the major food crops, together with recommendations on fertilizer use, pest control, and other improved practices for their production, to double or even triple yields within a five year period. We have ample evidence from widespread research and demonstrations with wheat, rice, corn and sorghums that such magnitude of increase is possible in extensive areas in Latin America, Asia and Africa. These research centers have helped to bridge the knowledge and materials from temperate zone agriculture into the tropical and subtropical conditions characteristic of most food deficit nations of the world.

It is important to recognize that substantial adaptive research and evaluation will be essential to fit the partially suited innovations from the regional or international centers into precise and fool-proof use in specific environments. We did not transfer corn hybrids from the corn belt to the Southeastern States of North Carolina and Georgia without an intensive adaptive research program in those States. The Mexican wheat growers in the Yaqui Valley received their new varieties and production practices from research at the local experiment station at Ciudad Obregon and not directly from the National Re-

search Center at Chapingo. They have developed confidence in Mexico's well oriented, nation-wide research program because they know the experiment station soils and environment at Obregon are characteristic of their farm lands.

The corn growers in Africa and Asia will demand changes that suit their conditions and will be as unwilling to accept foreign or distant innovations as were the corn growers outside of the U.S. corn belt in the 1930s and 1940s. The rice farmer of Kerala, India, will utilize the advances of the research of the International Rice Research Institute in the Philippines only after he is convinced that they are dependably superior to what he now knows and uses.

Leadership Is Essential

How do we move innovations from the major research resource centers with their excellent facilities and multi-scienced staff to the multitude of cultivators? As a start it would seem reasonable to focus on establishing national systems of agricultural science and technology since the adequacy of food and fiber must be of concern to central governments. India and other countries are increasingly aware that responsibility for agriculture cannot be exclusively, or largely, a "state subject." Leadership for research to improve agriculture is essential at the national level and a nation-wide system of research stations, staffed with scientists trained to identify the multiple factors that inhibit the growth of the agricultural industry should have high priority in our technical assistance efforts. We have had such national servicing from the research of the U.S. Department of Agriculture for more than a century.

In the United States our Land-Grant Colleges and Universities have provided most of the network or system of research centers that produced solutions to the specific hazards of precise environments. The state experiment stations and branch stations, together with the federal field stations, have furnished excellent coverage for farmers throughout the United States.

The limitations on trained personnel and financial resources in the food deficit nations would preclude the development of a national system as extensive or intensive as that of the U.S. The location of the regional research centers within these countries should be selected with care to insure attention to major variations in cropping patterns.

The use of the central and regional research stations within a given country, where the larger number of trained scientists would be located, as centers for education, would insure maximum use of facilities and staff, and furnish education under conditions where the related research would have maximum orientation to rural problems. Because of the substantial investment required for these research and education centers, it would seem essential that they be furnished through the public sector, with either federal or state funding.

As we look at the need for incentives to encourage farmers to change in traditional agriculture, it is apparent that maximum persuasiveness and enterprise will be required. Private industry could play a most significant role as the extension arm or the major agent of influence in guiding innovations into use. It is, of course, helpful when he who conducts the demonstration is in a position to deliver the new improved seed, the fertilizer or pest control materials.

Although we might expect the public sector to furnish the principal support in research and education, and private industry in the extension and materials production aspects, it would be essential to arrange for close, continuous linkage between the research centers and the private industry groups, possibly through extension specialists at the research stations, to insure constant up-to-dateness on innovations and the feedback of problems into the research centers. The industry organizations would require well trained technical personnel, capable of understanding the usually complex interactions between combined innovations, and able to conduct adaptive research for specific areas or conditions.

The private sector should expect to participate in support of education. The companies will draw upon the limited numbers of trained personnel in the host countries and should help replenish the supply through in-service experience with their companies abroad, and in the United States, and through scholarships at indigenous education centers as well as advanced training at U.S. institutions.

Careers Will Be Provided

The establishment of agricultural industries *in the developing countries would provide excellent career opportunities for well trained technical personnel and could be an important factor in reducing the "brain drain" of well trained scientists to the U.S. and other countries.* Special steps might well be taken to recruit scientific foreign students now enrolled in U.S. universities whose training could be adjusted to provide technical guidance to new commercial ventures in their home countries.

It will, of course, be possible for U.S. government agencies, universities, private foundations and industries to supply only a small portion of the technical and economic resources required to modernize agriculture in the many developing countries throughout the world. The major financial support, together with appropriate attention to the conditions that will attract private investments, must be supplied by the host governments.

The agricultural industry in the United States evolved as advances in science and technology, primarily from federal and state research centers, furnished the opportunities for private enterprise to contribute specific goods and services. Science and technology are even more important in increasing production in many of today's food-deficit nations, where added land resources are limited and private industry must play a prominent role in accelerating the scientific revolution in such areas of the world.

The development of national systems for agricultural science and technology can be achieved in a number of countries with current or future needs for expanded food production, with only minor modifications in their institutional patterns and by strengthening present deficiencies in facilities and personnel. The Government of India has taken steps during the past decade to improve the national agricultural research programs for crop production. A number of agricultural universities are being established in India to furnish centers for research and education in major agricultural areas. Improved varieties of some food crops are available, together with information on soil fertility, water management, and disease and pest control. A research system is, therefore, in the making and the principal missing element is the effective linkage, through adaptive research and demonstrations of the new materials and techniques, with farmers or cultivators who must still be convinced that the innovations will fit their conditions. The national research programs and the state agricultural university systems should be strengthened substantially but the pattern is established.

Similar opportunities for developing national systems of agricultural science and technology, with well selected and coordinated additional support, exist in a number of countries in Latin America, Asia and Africa.

Private Industry Help Is Welcome

The Agency for International Development is most anxious to work with private enterprise in assisting developing nations to achieve their goals for economic growth and social progress. A number of the research projects supported by the Office of Technical Cooperation and Research will furnish guidance for opportunities, and will identify problems for private enterprise abroad. The Office of Development Finance and Private Enterprise is prepared to furnish guidance to investors and has assisted numerous U.S. foreign investments in the agribusiness field, with about 120 projects in the developing countries for which over $350 million in Specific Risk Guaranty contracts are outstanding. The catalog of Investment Information and Opportunities lists over 200 items in the agribusiness field and Cooley loans as well as dollar loans may be available to assist selected projects. The conditions in hosts countries must be reviewed for the specialized industries so guidance should be obtained from the Office of Development Finance and Private Enterprise of A.I.D./Washington as well as from the A.I.D. Mission in the country where the investment will be made.

We have learned to join forces in close collaboration between the public and private institutions concerned with agricultural development in the United States. The magnitude of the task in meeting world food needs in the decades ahead furnishes an unequalled challenge to address this experience to international dimensions.

Dr. Moseman's remarks are published by the Foundation because of their special interest to Agribusiness, that complex of farmers, ranchers, industrialists, business and transportation men who create America's abundant supply of food and fiber. The Foundation assumes no responsibilty for the opinions expressed by the author.

Inquiries regarding reprints should be addressed to:

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ABOUT THE FOUNDATION

Objectives

On March 31, 1945, the Foundation was incorporated as a non-profit, educational institution. It was created by a group of nationally prominent farm organization and business leaders. Its primary purpose has been and is to inform the individual and the public with reference . . . to American agribusiness; conduct appropriate scientific research; cooperate with institutions of learning . . . by making available . . . reports and publications on agribusiness subjects; publish articles . . . by persons prominent in agribusiness . . . and avail itself of all recognized media for the dissemination of its educational programs. A further primary purpose of the Foundation has been and is to increase understanding throughout rural and urban America of the role agribusiness plays in our total economy. To accomplish these objectives, it has worked diligently during the past twenty-one years.

Programs

A few examples, selected from many, of the action programs originated by the Foundation but carried on as separate corporate undertakings are: The Farm Film Foundation which distributes 16 mm. educational motion pictures; The Rural Radio Research Foundation; the National Farm-City Committee, Inc. which sponsors National Farm-City Week and year 'round activities directed toward the elimination of misunderstandings between rural and urban citizens; an "Operations Committee" which conducts Agribusiness Symposiums at land-grant colleges; an Informal Committee on Crop and Livestock Reporting. . . . The Foundation underwrote part of the agribusiness study made at the Harvard Business School

RESEARCH NEEDED FOR TECHNOLOGICAL KNOWLEDGE IN AGRICULTURAL DEVELOPMENT

ALBERT H. MOSEMAN
Director for the Agricultural Sciences
The Rockefeller Foundation

A paper presented at the
Conference on the Economic Development of Agriculture
November 9-12, 1964

Ames, Iowa

RESEARCH NEEDED FOR TECHNOLOGICAL KNOWLEDGE IN AGRICULTURAL DEVELOPMENT

Professor John Kenneth Galbraith, in his distinguished lecture at the annual meeting of the American Association of the Advancement of Science in Cleveland, Ohio, last December, stated "under conditions of scarcity and human privation there is obvious need to get as much as possible out of the productive resources that are available -- to use the labor, capital, natural resources and intelligence of the community with maximum efficiency. Such effort enlarges the supply of goods and thus mitigates the pressing problem of the society, which is the scarcity of needed things."[2]

As we study the materials and practices in traditional agriculture, we are impressed by the fact that by and large farmers are making rather effective use of the resources at their disposal. Centuries of experience and exposure to the factors that inhibit agricultural production have guided the use of practices that are most certain to give a high average return for the labor and other inputs that are available. The experience of more than two decades of assistance in rural development has demonstrated the futility of attempting to reshuffle indigenous practices and materials. This merely brings about a realignment of basic inadequacies.

Added inputs from agricultural technology -- the accumulation and application of new knowledge and materials -- are essential if traditional agricultural practices are to be changed. Research to furnish the technical knowledge required in agricultural development may be adaptive -- to fit known improved technics and materials to diverse conditions, or it may involve background investigations, -- to improve understanding of the physical and biological interactions in environments that have been explored inadequately to permit the evolution of effective inputs.

THE RESERVOIR OF AGRICULTURAL TECHNOLOGY

The productivity of agriculture in the United States indicates the potential for change in primitive crop and animal husbandry. The new semi-dwarf wheat variety "Gaines," developed in the cooperative research program of the U.S.D.A. and the Washington State Agricultural Experiment Station, produced 136.6 bushels per acre under rainfed culture on a 40-acre field near Pullman, Washington, and 168.8 bushels per acre on 26 irrigated acres near Quincy, Washington, in 1964. Another report, less well confirmed, of a yield of 190 bushels per acre on 6 acres planted to this variety suggests that the 200 bushel per acre level is not out of reach.[6]

The 67.3 bushel national average corn yield in the United States in 1963, with several states averaging above 85 bushels per acre, is further evidence that many countries should be able to increase [illegible] three- to four-fold. The production of 50 bushels of corn per acre [illegible] inches of rainfall during the growing season, in recent experiments [illegible] Great Plains, also demonstrates the potential for increased crop production for those countries in the arid and semi-arid regions.

These, and many other examples that could be cited of the remarkable advances in our agricultural productivity, reflect the continuous infusion of technology into all aspects of the agricultural industry of the United States. These technical inputs have not just appeared, they are the result of planned and directed research, in genetics and breeding to improve crop varieties; in chemistry and soil science to guide soil, crop and water management; in various scientific fields to evolve more effective measures for the control of diseases, insects, and weeds; and in engineering to increase the efficiency and simplicity of operations at all stages of production, harvesting, [illegible], and

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marketing of farm products. The synergistic effect of combined scientific advances is perhaps the most significant, yet the least appreciated feature of agricultural technology in the United States. The concurrent development and application of new technics and materials, to minimize simultaneously the several major factors or problems that inhibit agricultural productivity, requires a high degree of planning and organization of research.

In some situations it is clearly evident that more background information is needed and that the integrated application of modern science and technology should yield prompt and substantial benefits. The low yields of rice in many of the heavily populated countries of Asia provide a prime target. The average production of less than 1,300 pounds per acre in India, Thailand, and the Philippines is far below the 4,000 pounds in Japan and the 3,200 pounds in the United States. The varieties and cultural practices of the temperate-zone rice areas of Japan and the United States are not directly suited, however, to the tropical areas of the "Rice Bowl" where the "indica" types or varieties that have been selected under low soil fertility conditions do not respond to high levels of nitrogenous fertilizers. In order to launch a well-rounded research attack on low yields of rice in the humid tropics, the Ford and Rockefeller foundations, in collaboration with the Philippine Ministry of Agriculture and the University of the Philippines, established the International Rice Research Institute at Los Baños, in 1962. This modern research, training, and documentation center, where field and laboratory studies are conducted in a coordinated manner by a team of scientists qualified to investigate, simultaneously, the many factors that limit rice yields, already shows promise of furnishing a much needed supply of new technology to transform Rice Bowl agriculture.

Yields of other food crops are extremely low in humid tropical areas, and dietary conditions range from acute hunger to various stages of malnutrition, with protein deficiencies widespread. Several organizations, including private foundations and the Latin American Science Board of the National Research Council, are studying the feasibility of establishing specialized, multi-disciplinary research centers in the tropics to build a better base of understanding of crop and livestock production problems.

THE INTERNATIONAL EXCHANGE OF IMPROVED MATERIALS AND METHODS

"Half of the total crop production of the United States, measured in dollars, comes from plants first used by the Indians, but wheat, our leading food grain, is not among them. It came to us from halfway around the world as food for colonists in the New World or in the luggage of immigrants, who knew its worth. The introduction of wheat from many lands provided an array of varieties and kinds for colonists to try. Many kinds failed because they were not suited to the soil and climate in the places they were planted, and they were replaced by seed from varieties that did succeed. Wheat became established by this process along the Atlantic coast before 1800. The process was repeated as settlers moved westward. Wheat was beginning to look like a native in America by 1859. Now it is grown regularly in 44 states."[5]

The foregoing statement, from the 1962 U.S.D.A. Yearbook, serves as a reminder that a large part of our agricultural abundance stems from imported resources and that a substantial period of trial and error, with many combinations of seeds, soils, and climates was required to achieve the widespread, dependable production of our principal food grain.

While it is possible to identify some successes in the cooperative efforts to improve agriculture through foreign assistance programs, we find, too frequently, ineffective or disappointing results. Many of the so-called technical assistance projects in agriculture during the past two decades have been designed merely to peddle the fruits of our agricultural technology. We have tended to follow the "plant it and hope" process that our pioneer families used to select, eventually and after frequent failures, the wheats suited for the many new and varied environments across the United States. Not enough attention has been paid to the type of guidance that agricultural science can furnish, and is achieving in the record wheat yields in the Pacific Northwest. It is essential to distinguish between the production line and the product of agricultural technology if we are to make significant progress in agricultural development efforts. This production line involves the studied attention to limiting factors at all stages in the growth and development of crops and livestock and the evolution of efficient and effective means to overcome them.

Adaptive, interdisciplinary research has made it possible to increase food crop production in a number of countries during the past two decades. The improvement in corn production in Western Europe following World War II, through mutual efforts of public and private organizations of the United States, the Office of European Economic Cooperation, and the Food and Agriculture Organization of the United Nations is one example. The successful implantation of science and technology in the agricultural development process in Western Europe is indicated by the steady increase in yield per acre of corn in these countries. The rapid and measurable progress in this transfer of technology was due in large part to the sound

planning of the research to evaluate adaptation of the plant materials, to the attention to seed production and marketing, and to other pertinent factors. The strong institutional base in Western European countries and the similarity of climates also facilitated the adoption of advances from United States agriculture.

In Mexico, wheat yields have been increased from an average of about 7.5 bushels per acre in 1945 to 32.7 bushels in 1963, and an estimated 39 bushels in 1964. A portion of this progress must be credited to the policies of the Mexican Government in increasing the acreage under irrigation, from 2 million in 1946 to 6.2 million in 1963; but the continued improvement in varieties, heavier application of fertilizers, and better water management practices, learned through the well-organized and sustained cooperative research program of the Government of Mexico and The Rockefeller Foundation have been essential to Mexico's achievement of self-sufficiency in wheat production.

The transferability of productivity through agricultural research is exemplified also by the international dimensions of cooperative wheat improvement research. The dwarf variety, Norin 10, introduced from Japan by the U.S.D.A. after World War II, was used in the breeding of the high yielding Gaines variety in the Pacific Northwest. It is also a basic parent of the several short-strawed or semi-dwarf varieties that have produced up to 120 bushels per acre in the Yaqui Valley of Mexico and that occupy more than 85 percent of Mexico's wheat acreage. These Mexican wheats have proved to be exceptionally productive in India, and it is expected that with some modification or reselection they will provide a significant boost to India's urgently needed food supplies in future years.

It has been found that wheat and rice varieties bred under the day-length conditions in Mexico, Colombia, and the Philippines have wider adaptation than most of the photosensitive varieties developed in temperate zone areas. Some varieties of crop plants are sensitive to length of day and will not flower if daylight exceeds 12 hours. Other varieties are not so photosensitive and will flower a certain number of days after they are planted, regardless of the length of day. This trait is important in the tropics where it is frequently possible to select early maturing varieties, that will produce, for example, a rice crop in 100 to 110 days and thereby permit the growing of two or three crops in a 12-month period. This characteristic of nonsensitivity to day length is being incorporated in the varieties developed at the International Rice Research Institute to extend their adaptability in tropical regions. Similarly, wheat varieties from Colombia, where a sustained research program over the past 14 years has produced a four-fold increase in average yields, have been sent to about 35 other countries. Kenya, Peru, Ecuador, Bolivia, and Guatemala are growing wheat varieties selected in Colombia.

Research in corn improvement in Mexico has produced hybrids that will yield 150 to 200 bushels per acre under irrigation. Hybrids capable of yielding over 160 bushels per acre have been created in Colombia and all of the new corn hybrids developed in India since 1957 include at least one inbred line originally selected in Colombia. These materials are being extended still further into Asian countries by cooperative research projects in Thailand, Indonesia, Viet Nam, and the Philippines, and a new corn belt is in process of girdling the globe.[7]

The increased interchange of crop germ plasm stimulated through the Food and Agriculture Organization of the United Nations, the International Cereal Crop Disease Nurseries of the U.S.D.A., and the international crop improvement research projects of The Rockefeller Foundation should help to accelerate the development of improved, adapted varieties throughout the world. The success of such endeavors will depend largely, however, on the adequacy of the research to evaluate the suitability of the varieties to new environments and to provide effective solutions to the mosaic of problems confronting farmers in primitive agricultural societies.

GOALS OF TECHNICAL RESEARCH IN AGRICULTURAL DEVELOPMENT

In responding to the question of the research needed for technical knowledge in agricultural development it is relatively simple to tally up the potentials in agriculturally advarced nations and to note the problem areas in need of more study. It is equally feasible to select a few outstanding examples of success in the transfer of the benefits of technology to upgrade primitive agricultures. The increasingly widespread recognition of such successful technical assistance efforts as the breeding and extensive use of more productive crop varieties may tend, however, to create the impression that agricultural research is little more than an "international Johnny Appleseed" endeavor and that the reshaping of materials for farmers to use in various parts of the world is the most significant role of agricultural scientists. Actually agricultural science can and must do more than provide spare parts that hopefully someone will assemble into a productive farming machine.

The transformation of American agriculture into its present stage of efficiency and productivity, through mechanization, chemicalization, and

other applications of science and engineering, was an evolutionary process that extended over several decades. We do not fully understand all of the many factors, and their interactions, that were involved in this advance but we do know that there has been a steadily growing appreciation, on the part of farmers, others in the agricultural industry, and among government leaders, of the benefits of science and technology in agriculture. This awareness and responsiveness is yet to be instilled into most of the societies with primitive cropping and livestock production practices but it must become an essential ingredient if the infusion of technology on a self-generating, sustained basis is to be successful in the many countries that face growing gaps between populations and food supplies. Agricultural scientists participating in technical assistance should reassess their goals and sharpen up their targets to be sure that the basic understanding and appreciation of the role of science and technology becomes a part of the development process in the less well-developed nations.

Demonstrating Potentials for Agricultural Progress

It is not uncommon to hear that national planning commissions in developing countries tend to devote 90 percent of their discussion time and 10 percent of their national budgets to problems of agriculture. Well planned research can and should demonstrate the potential for progress in the agricultural sector and encourage, as well as guide, increased national investments in agricultural development.

Agricultural scientists have an obligation to dispel the notion that research is a plodding, time-consuming process and that impatient nations cannot wait for the inputs from agricultural research. Today's

agricultural science is responsive to a demanding clientele in the United States where farmers and others in the agricultural industry expect a continuous flow of innovations from research fields and laboratories. Developing nations must be aided to recognize that haste and waste are associated if development projects proceed without adequate research guidance.

The "Problem-Orientation" of Research

A significant factor in the improvement of agriculture in the United States was the determination with which scientists of the U.S.D.A. and the land-grant colleges addressed themselves to the critical problems that inhibited agricultural production. There was less concern several decades ago about the classification of research into "basic" or "applied" fields. Too often the well-trained scientist in a country with primitive agriculture feels that he must be concerned with so-called fundamental research, in order to maintain his stature in the international community of scientists. He suspects that he might be downgraded if he devotes his research efforts to producing something useful.

Perhaps we are contributing to this concept through today's graduate training, and it might be worth while to reflect on the words of Dr. Walter Spieth of the Georgetown Clinical Research Institute of the Federal Aviation Agency, who suggests, "scientific research is only good or bad, not basic or applied. Good science consists of original thinking about careful observations in interesting situations, and frequently a practical question is the stimulus for it. The false dichotomy of 'basic' and 'applied' too often re-enforces a preciousness or snobbery in the graduate student that narrows his vision for years after leaving the academy. Some never recover."[8]

Research for agricultural development must be addressed to the modification of practices on the land. In training research scientists it is essential that they learn to recognize and work on meaningful projects. During the past three years a cooperative program of The Rockefeller Foundation, the Food and Agriculture Organization of the United Nations, and the Government of Mexico has provided in-service training in field, laboratory, and greenhouse research for 30 young scientists from Near East countries concerned with wheat and small grain improvement. They not only became acquainted with a wide range of plant germ plasm but received instruction and experience in the applied aspects of plant breeding, agronomy, soil science, irrigation, plant pathology, and cereal chemistry. These young men have learned that the integrated application of knowledge from all of these fields is essential to progress in wheat and small grain improvement.[7]

Encouraging the Effective Use of Research Resources

The importance of coordinated research programs that have responsible guidance at the national or regional level, and with flexible participation by research stations throughout the relevant environment, has been demonstrated through the extensive cooperative research of the U.S.D.A. and the state agricultural experiment stations. This also is the pattern followed in the agricultural research of the Canadian Government, and by The Rockefeller Foundation in its cooperating programs in Mexico, Colombia, Chile, and India.

The cooperative corn improvement scheme in India, from its initiation in 1957, was planned to demonstrate the value of coordinating and combining the research resources of the central government and of the states.[4]

The rapid development and release of improved hybrids, capable of yielding up to 150 percent more than commonly grown varieties in all important corn growing areas of the country, has focused the attention of Indian government leaders on the plan of the coordinated corn research project and has stimulated the decision to reshape other agricultural research into the same pattern. Similarly, the development of the agricultural universities in each of the Indian states, under the guidance of the land-grant universities of Illinois, Ohio State, Missouri, Tennessee and Kansas State, and financed by the Agency for International Development has furnished the bases for the overlay of central government support of research and for combined attention to national and local research needs.

The planning of the corn improvement research project in a manner that encouraged the development of a national system of research and education may well prove to be the most significant contribution of this cooperative research effort.

Guiding Investments in Agricultural Development

Dr. Raymond Ewell, in his discussion of "Fertilizer and Famine" at the American Chemical Society meetings last September, predicted that if Asia, Africa, and Latin America are not using quantities of fertilizer approaching 30 million tons by 1980 (equal to total world fertilizer use today), they are almost certain to be engulfed in widespread famine. Dr. Ewell stated, "The consequences of the population explosion have been discussed and analyzed in theoretical terms for a decade now, but the time for theory is nearing an end and the time for action is here."[1]

The task of increasing world fertilizer production to 100 million tons of plant nutrients in 1980, from the present level of 30 million tons,

is a challenging one. Equally, if not more challenging is the task of determining how these essential fertilizer inputs can be used effectively in increasing world food supplies.

In many countries with traditional agriculture, crop varieties have been selected to achieve maximum inherent yielding capacity under conditions of low soil fertility. They may produce slightly higher yields with modest applications of fertilizers but generally they respond with excessive vegetative growth and become susceptible to lodging, diseases, and other yield-reducing factors when large amounts of nitrogen are applied. In a study conducted in East Pakistan in 1962 by Japanese rice specialists, it was found that heavier applications of nitrogen, at the upper levels of the rates that ranged from 26.2 to 80.3 pounds per acre, actually resulted in a decrease of 8.6 pounds of rice per acre for each pound of nitrogen applied.[3] Similar results have been observed at the International Rice Research Institute in the Philippines. Varieties commonly grown in the Rice Bowl countries of Asia that produce average yields of 3,500 kilograms per hectare at Los Baños with an optimum application of about 30 to 40 kilograms of nitrogen per hectare, dropped to about 2,000 kilograms per hectare when the nitrogen application was raised to 80 kilograms. The semi-dwarf, stiff-strawed, early maturing, disease resistant varieties selected at the Institute have produced yields of 5,500 kilograms per hectare, without lodging, when 80 kilograms of nitrogen were applied.

The experience with wheat varieties developed for low soil fertility is similar to that with rice and emphasizes the need for integrated research in plant breeding and on soil fertility and water management practices if the added tonnage of fertilizer which must be used to meet world food needs

is to be effective in achieving this goal. Until such research can furnish more assurance of positive relations between fertilizer inputs and yield we would agree with Hopper that "care should be exercised when fertilizer and other practices involving an economic cost are recommended with the implicit promise that yield will go up as a result of their use."[3]

Another example of the need for more precise guidelines for a substantial investment to increase agricultural production involves the livestock and dairy industries in Chile. Plans are under consideration to import substantial numbers of cows of beef and dairy breeds to build up herds to a level adequate for domestic milk and meat requirements. There are many unanswered questions that should be resolved through an intensive, integrated research program on the cause of low fertility and low calving percentages in Chilean cattle, on the production and management of forage and feed supplies, on the control of animal diseases and parasites, and on other factors that now pose threats to the soundness of a substantial investment for the importation of the breeding stock.

Agricultural researchers must assume some responsibility for the isolation of significant problems and for planning and conducting the integrated investigations to furnish the combinations of answers required if the returns for foreign aid funds are to meet expectations.

Insuring Farmer Acceptance of Innovations

Studies to determine the factors involved in acceptance of innovations in traditional agriculture are frequently focused on questions of motivation and on social-traditional factors in the acceptance of something new and different. Inadequate attention has been given to the magnitude of the

change -- and the increase in return -- necessary to insure rapid diffusion of innovations. Hopper points out that in East Pakistan a potential 30 percent increase in rice output (and 20 percent increase in net income) has not been enough to cause a rapid diffusion of improved paddy production methods. On the other hand, new methods that offered a three-fold jump in potato production were rapidly adopted by cultivators.[3]

The complexity of combinations of changes necessary to boost output and income is another factor agricultural scientists must keep in mind as they develop innovations. Farmers reluctant to make a single shift from traditional practices find it difficult to adopt a large number of new technics or materials, such as improved seedstocks, changed planting and tillage methods, adjustments in soil and water management, and the use of fertilizers and pest control chemicals, concurrently or in proper sequence. The need for relative simplicity in innovations diminishes as farmers become accustomed to adopting new technics. In Mexico, in the third year of commercial production of the semi-dwarf wheat varieties Pitic 62, Penjamo 62, Sonora 63, Nadadores 63, Mayo 64 and Lerma Rojo 64A, and the dwarf variety Sonora 64, Mexican farmers had modified seeding rates, fertilizer applications, and irrigation practices to achieve the maximum benefit from the yield potential of the new varieties.[7] This farmer acceptance to change in Mexico has come only after years of research and demonstration of the benefits of combined innovations.

The training of extension specialists to insure their understanding of the importance of various combinations of inputs also should be a responsibility of those who develop the innovations. The man who peddles the goods should know what is in the warehouse.

Building Indigenous Research Organizations

The integrated research required to minimize or overcome the numerous factors that inhibit agricultural productivity requires strong, ably-directed institutions, and nationwide organizations that must be established and financed adequately by national governments if they expect to modify stagnant agriculture and to meet the constantly changing limitations in a dynamic agricultural industry.

Technical assistance to improve agricultural research and teaching too often has been implemented by the provision of a specialist -- a soil scientist, or plant geneticist, or entomologist -- when, in fact, the major indigenous deficiency has been the organizational leadership necessary to furnish the budgetary and administrative stability for sustained research efforts.

The establishment of local national research councils, or other bodies to administer funds for research grants, is a rather futile endeavor if a country lacks the well-staffed and organized research centers that can apply such grants effectively. The development of such stable indigenous research centers becomes especially critical as increasing numbers of trained young scientists return to their home countries to carry on research to supply a continuous flow of inputs into traditional agriculture.

SUMMARY

The significant modification of traditional agriculture will require substantial new inputs from science and technology. Some innovations may be derived from adaptive research, to fit the more productive materials and methods from advanced agriculture to new soils and climatic conditions.

In some instances, where past research and production experience has been deficient, integrated, interdisciplinary research programs shall be undertaken to deepen and broaden the base of understanding of agricultural production processes.

The levels of productivity achieved through agricultural research in the United States provide abundant evidence of potentials for increases of three- to four-fold in production of food and other agricultural materials in less advanced nations.

The international interchange of agricultural materials and methods is a centuries-old process. The slow and costly "cut and try" procedures for adaptation of innovations must give way to the studied and guided modification of materials and methods, with coordinated attention to the interrelated factors that combine to maximize productivity.

Substantial progress has been made in upgrading production of food crops in a number of countries through well organized, multi-disciplinary research projects, and an excellent research base has been established for rapid worldwide progress in the improvement of production of corn, wheat, rice, and other crops.

Agricultural scientists can and must contribute to the agricultural development process in roles that transcend the routine research to produce adapted materials and improved cultural practices. The task of instilling a sense of recognition of, and responsiveness to, the benefits of agricultural science and technology in primitive agricultural societies should be shared by agricultural scientists. This involves the demonstration of potentials for progress through agricultural research, the focusing of attention of indigenous scientists on research that is meaningful in removing obstacles

in production, the organization of research to achieve maximum return from the various internal and external resources, and the resolution of limitations or hazards involved in projects that require substantial investments to accelerate agricultural development.

Agricultural scientists must be alert to potential farmer acceptance of innovations and to the development of procedures for putting new technology into practice.

The structuring of indigenous research institutions should receive more attention to insure adequacy of the basic organization, and the responsiveness of administration, budget and fiscal procedures to the needs of the scientific staff.

REFERENCES

1. Ewell, Raymond. Fertilizer and Famine. American Chemical Society, Chicago, Illinois, September, 1964.

2. Galbraith, John Kenneth. Economics and the Quality of Life. Distinguished lecture, Annual Meeting, AAAS, Cleveland, Ohio. December 27, 1963.

3. Hopper, W. David. Some Reflections on Agricultural Technology: Inferences from Comilla. Paper prepared for the Overseas Representatives Conference, The Ford Foundation, September, 1964.

4. Moseman, A. H. New Research and Education Patterns in India. Symposium on the Agricultural Sciences for the Developing Nations. Publication No. 76 of the AAAS. Washington, D.C., 1964.

5. Reitz, L. P. Agricultural Research Service, U.S.D.A. Personal correspondence, October, 1964.

6. Reitz, L. P. The Improvement of Wheat. The Yearbook of Agriculture, U.S.D.A., 1962.

7. The Rockefeller Foundation Program in the Agricultural Sciences. Annual Report, 1963-1964. Office of Publications, 111 West 50th Street, New York, N. Y.

8. Speith, Walter. Basic Research on a Problem. Science, January 17, 1964.

PEST CONTROL - ITS ROLE IN THE U.S. ECONOMY AND IN THE WORLD

The complex biological world includes many species of life forms necessary to man's well being. It includes also many species that are debilitating or potentially lethal to man, and that endanger his survival. An ecological balance between these biological forces achieved only by natural events would make impossible the development of human society as it exists today.

As cultivation of the land to provide an increased and assured supply of food replaced the practice of merely gathering nature's produce, the balances of the complex plant and animal communities have been under constant adjustment, with the combatting of pests and diseases a major problem. The lack of understanding of the natural forces in the biological world hindered man's mastery of his environment for thousands of years. Only in the past century has persistent scientific investigation brought about effective methods for the reduction or control of destructive insects, diseases, weeds, and other pests. Only in recent decades have we achieved the capability to control or eradicate destructive and unwanted plants and animals from significant areas of our agricultural lands.

The development and widespread use of DDT, in the early 1940s, opened a new era for the exploration and use of chemicals that has special significance with respect to man and his environment. The control of insects, including disease-vectors harmful to man, has been a major force in expanding the human population of the world to a degree that places an extra measure of urgency on the effective control of pests that curtail food production.

Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the Public Symposium on Scientific Aspects of Pest Control, National Academy of Sciences - National Research Council, Washington, D. C.

January 31, 1966

Pest Control in the United States

The Agricultural Research Service of the U.S. Department of Agriculture has estimated the losses to agriculture from various hazards, the cost of controlling these hazards, and the cost of various inspection and quarantine programs to contain or restrict them. On the basis of information from 1951 through 1960, it is estimated that the average annual loss to crops, forest trees, and forest nurseries, and to livestock, poultry and their products during production is about $14,272,187,000. Additional losses during storage, marketing and processing of agricultural commodities and forest products are estimated at $2,279,774,000. Soil deterioration and weeds on farm lands and in canals add substantially to the above figures.

The dollar values are somewhat difficult to interpret because of the influence of the supply of a commodity upon price. The percentage of loss of a crop or livestock product, however, furnishes an effective guide to the severity of the particular hazard and to its total damaging effect to the agricultural economy. The losses to some of the principal agricultural crops from diseases, nematodes, insects, and weeds, as summarized in the U.S.D.A. Agricultural Handbook Number 291 "Losses in Agriculture", are as follows:

	Diseases	Nematodes	Insects	Weeds
Corn	12%	3%	12%	10%
Grain Sorghum	9		9	13
Rice	7		4	17
Wheat	14		6	12
Soybeans	14	2	8	17
Potatoes	19	4	14	3
Cotton	12	2	19	8
Sugar Cane	23		15	13

We can appreciate the significance of the losses to American agriculture from the above causes when we realize that the combined destruction to a single crop may range to 30 percent or more of the total potential yield. This may occur in spite of constant and generally effective measures to prevent such pests from building up into epidemic or epiphytotic proportions.

The highly industrialized agriculture of the United States has been served most effectively by the research that has perfected the chemical pesticides, cultural and sanitation practices, plants and animals resistant to diseases and insects, biological control measures, and such special techniques as sterilization and physical or chemical attractants, repellants, and rejectants. Progress in the development of a wide range of specific pest control measures will be reviewed in the sessions to follow, during the next two days.

Perhaps the most striking evidence of U.S. leadership in devising new concepts and techniques for massive control or eradication of pests is the work on the release of sterile insects which was used successfully in eradicating the screw worm in the Southeastern United States in 1958-59. The investment of approximately $10 million to eliminate this destructive pest has brought about an estimated tenfold return to the livestock industry of the region. The release of sterile flies also has been effective in control of the Mexican fruit fly along the California-Mexico border, in eliminating the oriental fruit fly from Guam, and is being studied for possible use on other insect pests. The use of bait sprays to eradicate the Mediterranean fruit fly from Florida and the combined use of a powerful male lure as bait together with the release of sterile insects eradicated the oriental fruit fly from the Island of Rota. These

accomplishments stem from imaginative leadership in biological research that is not always adequately recognized in a society that has come to take such innovations for granted.

U.S. agriculture and the economy generally has received the benefit of exceptionally enlightened and productive research during the past quarter century. Very few hazards to agriculture have been allowed to get out of hand, and those few - not for long. Despite the constant concern that is expressed over the potential health hazard of agricultural chemicals, we are still reassured by the fact that our scientists know of no instance of human cancer that has been caused by a registered pesticide, when it is used as recommended. We are aware of the need for constantly improved effectiveness and safety in pest control measures and a continuing strong research program is, of course, essential to achieve these dual objectives.

Research Abroad to Protect U.S. Agriculture

The constantly changing form of insects and diseases, with the continuing evolution of new virulent types with increased capability to attack hitherto resistant plant and animal hosts, is a phenomenon that is well recognized by scientists, although not usually so well understood by non-scientists. The importance of continuity of attention to disease and pest control is well recorded in the experience with wheat stem rust. In spite of the long history of research on the pathogen, and the development of a series of resistant varieties of wheat, the new race 15 B, which first appeared in commercial wheat fields in 1950, built up to massive and destructive proportions in 1953 and 1954 when 60 and 75 percent, respectively, of the potential durum wheat crop

in the United States was destroyed.

We are aware that the life span of a crop variety is relatively short. This may be illustrated by the experience in oat breeding and improvement in the United States during the past quarter century. In 1941, nearly all of the oat acreage in Iowa was planted to varieties susceptible to the smuts and rusts. The replacement of these varieties with new selections derived from hybrids involving the Victoria parent was approximately 90 percent complete by 1945, when the Helminthosporium blight appeared, causing losses to production of 25 percent in 1946 and 32 percent in 1947. The rapid replacement of the varieties with Victoria parentage, by new varieties derived from hybrids involving the Bond parent, reduced the losses to one percent by 1948. The latter varieties, however, were susceptible to race 45 of crown rust and to Septoria foliage blight, that caused losses ranging from 15 to 30 percent between 1949 and 1953, so they also were replaced from the plant breeding production line that fortunately continues to operate. This experience in meeting a constantly changing disease hazard demonstrates not only the need for alertness in our crop improvement research, but also furnishes evidence of the rapidity of adoption by farmers of new technical inputs, once they are aware of the benefits of science and technology.

New virulent forms or types of diseases and insect pests may exist abroad where they pose a constant threat because of a possible chance introduction into this country. The international exchange and testing of varieties and selections of wheat and some other cereal grains, initiated in 1919 between the United States and Canada, was expanded into a uniform rust nursery program during the 1940s. Following the appearance of stem rust race 15 B, steps were taken to expand the testing of wheat varieties in the Latin American countries,

beginning in 1950. In 1952, arrangements were made for growing large numbers of cereal crop varieties in several countries in Africa and Asia. At the present time, there are 64 spring wheat nurseries of approximately 600 entries, 32 winter wheat nurseries of 300 entries, 32 oat nurseries of 75 entries, and 48 barley nurseries of 150 entries, that are being grown throughout the world. These nurseries present a cross section of the best varieties emerging from the research programs of the world's leading plant breeders. There are approximately 150 scientists cooperating in this program, at 85 locations in 40 countries.

In some instances, where a given virulent disease form or type is known to exist, special studies are undertaken in the host country to determine sources of resistance or means of control. Research in Colombia in recent years has succeeded in developing sources of resistance in rice varieties to the Hoja Blanca disease, and also in identifying its leaf hopper vector. Other cooperative research in Colombia has isolated resistance in oats to a particularly damaging form of stem rust race number 6 which was found in that country. Similar research has been undertaken for livestock diseases and pests. The cooperative investigations in Kenya on African swine fever have been most productive in furnishing information for U.S. animal scientists and also in helping to establish a more effective research center for livestock diseases in Kenya.

There are many additional examples that could be cited of research on diseases and pest control abroad that redounds to the benefit of U.S. agriculture. It is recognized increasingly that this international exchange of materials and research information is essential as we become more and more interdependent internationally with respect to food supplies and other agricultural commodities.

Pest Control Problems in Other Lands

It is difficult to obtain precise and reliable evidence on the magnitude of losses to potential agricultural production from plant and animal pests in the less developed countries. The Food and Agriculture Organization of the United Nations is constantly improving estimates of agricultural production capacity and losses so we may expect increasingly reliable information in the years ahead. We can assume, however, that losses in most countries practicing traditional agriculture are as high as those in the developed countries, and are undoubtedly much greater because of the lack of well organized research and control programs.

The impending shortage of food grain in India, because of the widespread failure of the monsoons in 1965, focuses attention on the need, and the potential, to increase food supplies by reducing losses in indigenous production. It is estimated that insects, rodents, and other animal pests to food grains in the field in India consume about ten percent of the total production, while losses in storage are assessed at five percent of the quantities stored. Approximately 250 animal pests of crops occur in India, the majority of these being insects. Of the 87 million tons of food grains produced in 1963-64, about 56 million tons were stored by the rural population. A total loss of 15 percent on this crop would approximate 13 million tons or nearly twice the food grain imports of India during the past year. At an average value of 400 rupees or $84.00 per ton, this loss on the 1963-64 crop would amount to about $1.09 billion.

Of India's total of 376 million acres of cropped lands, approximately

283 million acres are planted to the food grains and pulses, based on the 1962-63 crop season. The total area, including all crops, treated with chemicals for insect and disease control in the last year of the first and second five year plans was 6.1 and 16.0 million acres, respectively. It is hoped that by the end of the third plan, in 1966, it may be possible to cover about 40 million acres with pesticides.

It is proposed to treat about 160 million acres with chemicals for the control of insects, rats and diseases in the last year of the fourth plan (1970-71), a fourfold increase over the third plan. Of this total, cereals will account for about 115 million acres and emphasis will be mainly on rice, wheat and sorghums.

The control of storage pests in India should become less difficult in the future as more grain is stored in large central distribution centers rather than in the rural areas.

As improved seeds, additional fertilizers and irrigation become available in India, corresponding increases in the inputs of pesticides will be required. The decision to introduce new crop varieties may well hinge on the resistance of the new variety to diseases and insects, or to adequate pest control measures. The shoot fly, Atherigonia, and the stem borer, Chilo Zonellus, are serious and destructive pests of sorghums in India. The new sorghum hybrid CSH-1, developed in the cooperative research scheme of the Government of India and the Rockefeller Foundation, is highly superior to local varieties in yielding capacity but is susceptible to insect damage. During the past summer season at Delhi, the new hybrid produced yield increases in the range of three to four tons per hectare when the stem borer was controlled. The more extensive use of

insecticides will be essential if India is to achieve the yield advantages of improved varieties and hybrids of sorghums and millets. In 1963, India had a total capacity to produce about 40,000 tons of pesticides (active ingredient) although the actual production was in the rangeof 15,000 tons.

Familiar Hosts - And Unfamiliar Pests

As new varieties of wheat, rice, and other food grains are introduced into food deficit nations for testing and for possible adaptive research to suit them to local growing conditions, special attention must be paid to disease and insect problems. We are well aware of the possibility that new races of rust may emerge to attack the high yielding, semi-dwarf, and dwarf wheat varieties introduced into India and Pakistan from Mexico in the past 2 years. Similarly, the Taichung Native 1 variety of rice from Taiwan that has performed so well in India in limited yield or demonstration trials is known to be highly susceptible to certain forms of the blast disease, *Piricularia oryzeae*. It also is susceptible to the Tungro virus disease and to certain leaf diseases in the Philippines. As productive new crops are introduced into developing countries for trial, it is essential that we know their weaknesses and take steps immediately, through adaptive research, to either incorporate resistance or develop other methods of control.

Many of the pests and diseases of crops may vary greatly depending upon whether these crops are grown under temperate, subtropical, or tropical condition. As U.S. scientists engaged in technical cooperation or assistance projects work with the crops with which they are familiar, but under conditions that are strange, and frequently much different, they encounter new and often difficult pest hazards. The stem borer, *Chilo Zonellus*, which attacks corn and

sorghums in India, as well as the sorghum shoot fly, Atherigonia species, have been mentioned previously as challenging new competitors to the plant breeders and entomologists who have worked during the past ten years to improve production of these crops in India.

Even greater disease and pest control problems confront scientists who are assisting in research to improve production of rice under tropical or subtropical conditions in Asia's rice bowl. We have achieved a high degree of sophistication in recommendations for rice production in the United States, with newsletters from our principal rice research field stations that outline in detail the conditions, materials, and practices that are conducive to high yields. Rice growers in the United States are given information on soil and climatic conditions; rotations; soil and seed bed preparation; seeding methods, rates, and dates; the selection of varieties; recommendations on rates, time, and method of applying nitrogen, phosphorous, and potassium as well as minor elements; on water management and weed control.

Precise instructions are given for the use of fungicides for controlling seedling blight through treatment of rice seed, and for water management for controlling the straight-head disease. Guidance is given for water and soil fertility management, to minimize the infection and spread of the blast disease.

Similar precise guidance is furnished for control of the rice water weevil, and for chemical treatments to control stink bugs when they reach a certain population. We have clear cut recommendations for the control of army worms.

This intricate recipe for rice production is the culmination of the coordinated investigations of the many scientific workers in the disciplines

related to agriculture and the U.S. rice crop is guarded against nearly all hazards that can be controlled by man.

There has been considerable research to identify diseases and pests of rice in other countries but the effectiveness of control measures is extremely variable, depending in part upon lack of information, and in part upon lack of dependable supplies of pest control chemicals. In India, 26 rice pests are listed of which 10 are considered serious, 10 moderate, and 6 mild.

Plots protected from insect damage at the International Rice Research Institute at Los Banos, the Philippines, produced from one to three tons more rice per hectare than those where insects were not controlled. These increases were approximately 50 to 100 percent over the yields of the controls except in cases of severe leaf hopper infestation where the yields of the treated plots ranged up to five times those of the controls.

The rice stem borers are the most widely distributed and important pests of rice throughout the rice bowl. Three species of stem borers, *Chilo suppressalis*, *Tryporyza incertulas*, and *Sesamia inferens*, as well as *Chilotraea polychrysa*, are the more prominent ones. The adult moths of the rice stem borer lay eggs on plant leaves and the larvae, shortly after hatching, bore inside the plant stem where they pass the entire larval period. The larvae feeding within the stem generally cut off the growing parts of the plant, resulting in a dead heart of a white head instead of a productive panicle.

Extensive studies have led to the conclusion that the gamma isomer of benzene hexachloride, used as a systemic by application in the water in rice fields, is the most effective method for controlling the rice stem borers. This insecticide, commonly known as lindane, has low mammalian toxicity, does

not affect the flavor of the grain, and can be applied easily in granular form with a minimum of equipment and training. The Institute suggests that appropriate national agencies in the rice growing countries establish applied research and demonstration trials to develop specific recommendations for use of the gamma BHC by local farmers. The Institute intiated such tests in a number of provinces in the Philippines in 1965 and also has assisted with large scale field tests with gamma BHC in Malaysia and India.

Gamma BHC, when applied at rates of two kilograms per hectare, caused less than five percent mortality to tawes, tilapia and carp fish. Plots which have received a total of 39 kilograms per hectare of this chemical over four cropping seasons have not shown any apparent accumulative phytotoxic effects and the residue of the toxicant in grain or straw is well within the tolerance limit.

Research on rice varieties has identified some highly resistant plants that are being utilized in rice breeding and selection programs.

There is increasing evidence that more attention should be given to losses from rice virus diseases and to control of the various leaf hoppers which transmit these diseases. Four kinds of virus diseases have been identified in the Philippines, including tungro, yellow dwarf, orange leaf, and grassy stunt. They differ in symptoms, varietal reactions, and the kinds of leaf hoppers which transmit them. In Taiwan, in addition to the four viruses found in the Philippines, a severe virus called "transitory yellowing" is seriously damaging. It is suspected that these diseases or variations of them occur in many other countries of tropical Asia.

The "penyakit merah" disease of rice in Malaysia has been established as a virus transmitted by a leaf hopper. Until recently, this disease had been classed with the "mentek" disease in Indonesia and the "suffociation" disease in Taiwan as a physiological condition. There is increasing evidence that many of the so-called physiological diseases of rice that occur widely in Southeast Asia are actually virus diseases.

There are four major virus diseases present in Japan, including dwarf, yellow dwarf, stripe, and blackstreak dwarf. It is possible that other diseases of unknown cause and considered physiological, such as "punsuk" in East Pakistan; "Mjit-po", "Annyit-po", and "yellowing" in Burma; "yellowing" in India; and "orange leaf" in North Borneo may also involve viruses. The use of sevin is effective for control of many virus-carrying species of leaf hoppers, with approximately two or three kilograms per hectare of active ingredient applied into the irrigation water every 15 days.

Gusathion and thiodan sprays effectively controlled both rice borers and rice leaf hoppers in field exeriments at the International Rice Research Institute in 1965. These foliar sprays have some advantage over the systemic treatments of gamma BHC or sevin since they also may control rice bugs which severely damage the crop by sucking juices of the developing grains. The rice bug is a serious problem in many areas of Asia and may be controlled by several of the standard insecticides including sevin, DDT, BHC, endrin, and folidol.

Research has been initiated in the past year on the sexual behavior of the rice stem borer moth to determine the feasibility of the use of chemical sterilants. Field investigations also have been initiated to determine the feasibility of biological control through the use of parasites.

The Gall Midge is a problem in India, Thailand, Cambodia, Ceylon, Pakistan and Indonesia.

Even when effective pest control measures have been developed in the nations with less-advanced agriculture, through well planned research, the problem remains of developing improved farm practices. In many cases, the pest control materials are not available, or the marketing or distribution systems have not been developed. Frequently, the supply lines and retail outlets are full of older and less effective products.

When two or more insects appear in rice fields, each requiring a specific insecticide, manufacturers tend to promote combination products which may be relatively ineffective because of the need for precision in time of application of the right chemical to control the specific insect. It is important, therefore, that close working relations be maintained between research institutions, commercial manufacturers and distributors, and farmer organizations.

Exotic Animal Pests

Farmers in a number of countries in Africa and Asia encounter serious losses from various rodents and birds, both directly and from crop or livestock diseases that are carried by these pests. African farmers have suffered heavy losses to their rice, millet, sorghum, and wheat crops from grain-eating birds, the most common being the "Mange-Mil, or Quelea. Each bird may consume from two to three grams of grain per day while destroying another 17 or 18 grams as they pick at the plants. The daily consumption of these flocks of birds is of the magnitude of 3,000 tons of grain, or 4 million tons per year in the Sudan-Sahelien area. This represents a loss of value in cultivated crops of over $200 million per year, not including the time and expense involved in fighting the birds.

The Quelea birds travel in flocks and devastate entire regions as they migrate from one cultivated region to another. At sunset the birds nest in trees or bushes, to which they return each night until the surrounding grain fields have been depleted. One tree may harbor as many as 2,000 birds at night and an effective method of control is to dynamite these sleeping areas or to burn the nests. It has been found that spraying with a 25 percent solution of parathion also is most effective and practical.

The countries of Chad, Cameroun, Mali, Mauritania, Niger and Senegal have organized collective or cooperative regional anti-Quelea campaigns. An intensive four-year campaign was initiated in 1964 to attempt to reduce the regional population of the Quelea so that the individual states will be able to control this pest with local resources in the future. The Food and Agriculture Organization of the UN and the Agency for International Development are furnishing support for this control program.

The control of rodents or field rats in rice fields is a serious problem throughout Southeast Asia. Results or benefits of community clean-up programs, the wide-scale use of poisons, and other approaches have proved to be only temporary. Baits of zinc phosphide, strychnine, and barium carbonate, and fumigation with calcium cyanide are used. At the International Rice Research Institute, a battery-powered electric fence has been installed to protect certain experimental plots and during the past calendar year more than 2,000 rats were killed. This type of fence is not suitable for wide-scale use because of cost and the high hazard to humans but it is an effective control for experimental plots.

Tsetse flies, as vectors of trypanosomiasis in livestock as well as in man, represent one of the major obstacles to economic development of approximately

three million square miles in Africa. In much of this area the only livestock that can be produced is poultry. Although scientists from several countries have made extensive studies of the biology and ecology of the insect in various parts of the continent, little progress has been made in developing effective and economic control measures. The Agricultural Research Service of the U.S.D.A. is now conducting investigations, financed by the Agency for International Development, to determine the possibilities of using the sterility method that was successfully applied in the U.S. for the eradication or control of the screw worm, fruit flies, the pink boll weevil, and other insect pests.

Throughout Latin America vampire bats are a most important vector of rabies. The cattle industry in Venezuela is reported to have declined by 50 percent since World War II, from 20 million head to about 10 or 12 million from rabies transmitted by the vampire bats. Other Latin American countries, including Mexico, have also reported serious losses. Bat rabies also may be transmitted by direct bite or by an airborn medium. Viruses other than rabies also have been isolated from the salivary glands of bats in California, Africa, and Trinidad which may be possible causes of encephalitis and hemorrhagic fever.

We can anticipate increasing progress in the control of many of the pests and diseases that are common and widely distributed throughout the world, as international collaboration in research is increased. It will be essential to enlist the cooperation of private as well as public organizations in these endeavors since the supply of pest control chemicals must be assured and in many countries manufacturing plants and reliable channels of distribution are yet to be established. Farmers in developing countries who are faced with new investments

for improved seed, fertilizers, and pest control chemicals must be supplied with effective and specific materials and concerted action must be taken to insure that old or less effective products are replaced.

We are confronted with a task in expanding world food resources in the years ahead that exceeds any past challenge to mankind. If world food supplies are to be increased by fourfold by the end of the century, the goal set by Director General B. R. Sen of the Food and Agriculture Organization of the UN, we must cut back the losses of 20 to 30 percent of the potential production of our crops and livestock that now occur commonly around the world.

There are no national boundries for the biological forces we are confronting, and scientific talents should be marshalled on an increasingly international, cooperative basis as we move forward to achieve and maintain the desired balance of man and his food resources.

MUSTERING RESOURCES FOR AND ADMINISTERING U.S. TECHNICAL ASSISTANCE*

I appreciate the opportunity to participate in these meetings and to renew acquaintances with non-A.I.D. colleagues engaged in foreign aid activities. The last time a Ford Foundation representative and I collaborated on a project in Washington, it was concerned with mustering resources for technical assistance -- a few years ago when we encouraged A.I.D.'s Far East Bureau and the World Bank to join forces with the Ford and Rockefeller Foundations to improve the facilities and program of the College of Agriculture of the University of the Philippines. Substantial progress has been made in mounting such joint efforts in recent years, and in improving cooperation between aid-providing organizations as well as with the developing institutions.

In technical assistance programs we are especially concerned with transmission of skills, resources, and techniques to accelerate human and economic development, and with the establishment of indigenous institutions to foster continued growth and development. The needs and opportunities for technical assistance are varied and complex, but the experience gained during the past two decades permits the more selective application of resources to development opportunities.

Shifting Targets and Objectives

The pattern of technical assistance for today's less developed countries is substantially different from the U.S. aid of Marshall Plan days. The cooperating countries of Europe, with their highly developed base of science

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*Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, to the American Society for Public Administration, Washington, D.C.

April 15, 1966

and technology, with high levels of literacy, and with the institutions or infrastructure to accommodate rapid economic rehabilitation were in a position to utilize sophisticated technological advances from the U.S.

The less developed countries of the 1950's and 1960's have been characterized as "poor, tropical, and agricultural." We do not fully understand their needs or potential responses to aid efforts. The Advisory Committee on Private Enterprise in Foreign Aid, under the leadership of Arthur K. Watson, Chairman of the IBM World Trade Corporation, in its report of July 1965, in recognition of the desperate race between population growth and food production, emphasized that research for agricultural development "justifies the greatest attention of A.I.D.," but the Committee pointed out that "our ignorance of what works and what does not is also evident in the fields other than agriculture. For example, we are unsure about the kind of public administration systems that might work in the varied circumstances of Latin America, Africa, and Asia. We are uncertain about the type of educational techniques and educational curricula that might be most appropriate to the state of literacy and kind of society encountered in these areas and, ironically enough, we are even unclear about the type of industrial technology which might be most appropriate to the little markets in underdeveloped industrial environments that are characteristic of the less developed world."

We are increasingly aware, as David Bell pointed out this morning, of the need to "learn how" and of the limitations of transfer of "know how" in assembling and applying foreign aid resources.

The world-wide concern that has emerged in the past three years over the rapid growth in population in the less developed countries, together with the recognized limitations in world food production capacity, has caused a significant change in emphasis in foreign aid efforts. We are now in the

process of learning how to conduct effective cooperative programs in family planning among peoples in societies with widely divergent beliefs or values. We are confronted with the task of developing manpower, resources through training and research programs in selected U.S. institutions and of evolving cooperative field programs guided largely by our current working experience. There is still uncertainty, and a divergence of opinions, with respect to the need for effective local or community health centers to service these family planning programs.

The Role of the Universities

U.S. universities have played a prominent part in foreign aid projects for more than ten years, and at the present time 126 universities, supported under A.I.D. contracts totalling $184.6 million, are providing research, training, and technical services for A.I.D. and are cooperating in technical assistance in 38 countries. Dr. John Gardner furnished a most helpful analysis of the university relations in his report in 1964 on "A.I.D. and the Universities." Dr. Norman Auburn, President of the University of Akron, spent the year that ended January 31 on a special assignment with A.I.D. to help develop improvements in A.I.D.-university working agreements.

In spite of this concerted attention, we are aware of inadequacies in the use of these important resources. For example, we are not realizing the full potential benefits of our land grant universities when we draw upon only the educational component of these institutions that achieved their special distinction because of their highly integrated research, teaching, and extension functions. We cannot expect to mold an effective indigenous institution in a cooperating country that will have the desired rural development impact when the U.S. institution furnishes only a limited academic or teaching faculty concerned largely with modification of curriculum. We must marshal the experiment

station or research components of the U.S. land grant universities and apply this resource, together with the education and extension sectors, in coordinated efforts to upgrade agriculture and rural development. Furthermore, we have been slow in appreciating the limited potential impact that may be expected from a single university in a country, in contrast, for example, with the results achieved from the combined and coordinated efforts of the 68 land grant institutions, together with the research and extension support from the U.S. Department of Agriculture, that furnished the system of research and educational guidance for the development of agriculture and rural areas generally in the U.S. over the past century.

Steps have been taken in recent months to establish or strengthen similar national systems of agricultural research and development in cooperating countries of Asia and Latin America. It is apparent that the food grain surplus nations of the world, including North America, Western Europe, and Oceania, will not be able to continue to meet the world-wide needs in the years ahead, with total food grain deficits of the less developed countries estimated to reach 42 million tons in 1975 and 88 million tons in 1985. Accelerated programs of adaptive research must be initiated promptly to increase indigenous production of food grains in the immediate years ahead, with training and institutional development programs geared to this adaptive research effort to establish the capability for the constant flow of innovations to meet future expanding food requirements.

It is desirable for these adaptive research programs to improve production of the basic food crops to be established in coordinated national systems in the recipient country to insure the maximum additive impact of the limited scientific manpower that can be furnished from the U.S. and that is available

in the host country. These expanded national programs can be expected to draw more heavily upon the capability of the U.S.D.A. research units, as well as on the experiment station personnel of the land grant universities, and will enlist support from the private foundations as well as other organizations with competence in this field. It will be essential to identify and utilize technical assistance resources on a world-wide basis if we are to avoid disastrous food shortages in the years ahead.

In recent years we have gained experience with different types of collaborative or consortia arrangements, to combine resources from different U.S. universities and provide a critical mass of talent for a given foreign aid objective. Such consortia have proved effective, particularly where the cooperating institution in the developing country is a well identified laboratory or center, such as the Indian Institute of Technology in Kanpur, India. In this instance the joint or collaborative support from nine U.S. institutions has worked out well.

In other instances, consortia arrangements may be less effective since they do not permit clear identity of responsibility and they furnish added points of contact and friction between the participating members of the consortia, as well as with the A.I.D. Missions. An effective pattern is evolving in the contract signed recently with the University of Nebraska to furnish assistance in the development of the Institute of Agriculture in Colombia. This project involves also the participation of the Ford, Kellogg, and Rockefeller Foundations. Mr. James Fowler, the A.I.D. Mission Director in Bogota, welcomed the participation of a U.S. land grant institution to furnish essential backstopping for the educational component of this nationwide agricultural institutional development effort, but was understandably hesitant about having more than one such U.S. university involved. Under the present arrangement,

the University of Nebraska will furnish such technical personnel as can be made available from its campus. The university, in turn, has developed an agreement with the Big Eight universities to supply specialized competence not obtainable from the Nebraska staff. The lines of communication are clear and direct between the A.I.D. Mission Director and the University of Nebraska, with the latter institution responsible for fulfilling the total staff requirements.

Private Enterprise

We appreciate the substantial contributions made in our own economic and social development through the force of the private industries that have furnished initiative and leadership on many fronts. Many American industries are anxious to participate more fully and effectively in helping to achieve the goals of our foreign aid program.

We have not yet found satisfactory or generally applicable guides for the involvement of private industry in development activities abroad, and perhaps this reflects some tendency to look upon "private enterprise" as an amorphous or monolithic structure, as some regard "Latin America." It is increasingly apparent that we cannot evolve patterns for such segments of the American private enterprise system as the steel industry, the fertilizer industry, or the food processing industry. Rather, it is desirable to identify particular needs and opportunities in the less developed countries and help match these with the interests and degrees of readiness of specific U.S. companies. A.I.D. is supporting special studies to identify such problems and opportunities, through the TVA to assess the world fertilizer situation, and Mississippi State University to review seed industry requirements in developing countries. Other program areas are under consideration.

We are aware that private companies must weigh the financial risks involved before they commit the investments of their stock holders to possible uncertain enterprises abroad. As stated by one of my professional colleagues, who was hopeful of enlisting support from a major U.S. company for his foreign assistance project, "the attitude and enthusiasm of the Chairman of the Board tends to vary, depending upon whether he is wearing his humanitarian hat or his corporate cap."

The more active participation of U.S. private enterprise in the foreign aid program is of real significance, and continuous joint efforts should be made to increase such collaboration.

Research

A research program was initiated within A.I.D. in 1962, in recognition of the need to study and develop more precise guidelines for the complex components of our economic and social development programs. Measured against our $17 billion annual national investment in research, the total of about $28 million committed to date for A.I.D.'s research is certainly modest. It is, however, most important.

We are focusing these research resources more and more sharply on the problems identified as handicaps in our field programs.

The question of "excellence" versus "relevance" is posed in the case of our research. At the present time much of the research in the U.S., especially in the universities or academic communities, is "opportunity oriented" rather than "problem oriented." Opportunity oriented research is that which stems from the ideas and curiosities of individuals, and provides answers for which we then identify problems or uses. In the advanced technology of the U.S., this flushing out of new ideas accelerates growth and development because we have the scientific and technological infrastructure that allows only a limited shelf

life for such advances in knowledge. In a developing country, however, it is essential to give first attention to applied or adaptive research that will eliminate or minimize problems of production and development, to remove the roadblocks to economic and social progress, building upon a relatively unsophisticated scientific or technological base.

It is important that we maintain flexibility in our research designs and adapt to the specific situations we are assessing. If we are developing information on a problem for which we have no precise experimental model, we should not permit rigid and fixed patterns for research investigation to restrict us unduly in obtaining useful information and understandings through well planned field experience. This may be necessary, for example, to develop essential understandings with respect to the infusion of innovations in unfamiliar societies. We are addressing a multitude of unknowns in applying resources in economic development. In our research efforts, we should avoid being foolish, but we should expect to be venturesome and to take some calculated risks in investing research funds.

Pluralism in Foreign Aid Resources

The new initiatives in the programs proposed for fiscal year 1967 in international education, health, and food and agriculture promise to add greater dimensions to collaboration in these fields, with additional public and private agencies more actively engaged. The Agency for International Development will continue to have primary responsibility for cooperative efforts abroad designed to bring about economic and social development.

If we are to maintain a reasonable sense of order and direction in increasingly complex international activities, it is essential that we develop and maintain a high level of leadership capability within the principal

participating agencies, including A.I.D. As pointed out by John Gardner in his report on "A.I.D. and the Universities," "There is an unspoken assumption in many quarters, particularly among university people, that whenever A.I.D. really needs talent all it has to do is to write another contract. This is a grave mistake. A.I.D. cannot intelligently administer an extensive contract system unless the best of its direct hire personnel are able to deal with development problems at the same professional level as the best university people. It must be in a position to bring first class, intramural judgment to bear on a question. Furthermore, its relations with the universities will never be established on a sound basis until it has on its own staff the caliber of professional personnel who can deal with university people on equal terms. This is a lesson the Office of Naval Research, the National Institutes of Health, the National Science Foundation, and other agencies learned long ago."

The need for a strong intramural staff is especially critical with expanded participation of U.S. universities, private industries, and other Government agencies. As David Bell stated this morning, we have strengthened the capability of our A.I.D. Mission Directors to deal with broad questions of development policy in the field. We are also attempting to strengthen the professional staff in Washington, to improve the technical backstopping, and help our field staff keep abreast of the best new technology the U.S. has to offer.

Personnel Recruitment

Many of the leaders of our Government have emphasized that next to the achievement of peaceful coexistence among nations, our most important challenge is to assist developing countries to equalize opportunities and levels of living for people throughout the world. This is a matter of deep concern to increasing numbers of leading scientists and educators in the United States who have a real interest in contributing to our foreign aid program. However, the

lack of emphasis on science and technology as a basic component of our foreign aid effort during the past fifteen years has perpetuated doubts in the minds of professional people in the U.S. that we are really serious about building a solid base of science and technology into our technical assistance program. We hope to dispel this concern.

An additional limitation in the recruitment of capable direct-hire personnel for the Agency for International Development is the impression that our foreign aid program is temporary. This stems from annual authorizations, periodic changes in organization, and certain shifts in focus or objectives. In reality, we have had a program of U.S. foreign assistance since the Lend-Lease Act of March 1941, which was designed to bolster the resistance of the Allies to Axis powers. This was followed, in March 1942, by the establishment of the Institute of Latin American Affairs, to furnish U.S. help to develop the resources of our Latin American neighbors. As we look at the record of commitment of our Government to foreign assistance, and as we view the present inequalities in well-being among the people of the world, we can be fairly certain that we will not soon put aside a job that is yet largely to be done.

The lack of a constituency for the foreign aid program and the absence of a long-term continuing commitment on the part of the Congress and the citizenry of the U.S. is a serious handicap in attracting additional capable leadership for the planning and operation of our programs.

President Johnson in his Foreign Aid Message of February 1, after outlining the needs of developing nations, stated "our response must be bold and daring." This reflects the new order of urgency in our foreign aid effort as we cooperate in meeting the problems of inadequate food supplies, rapid population growth, and health and disease problems that are increasingly critical. It has been suggested that a man cannot be caused to hurry if he does not know

where he is going. We realize, therefore, that it is essential, not only for A.I.D., but also for other public and private foreign aid agencies to have the strongest possible intramural staff -- to help identify the objectives and the pathways for an accelerated foreign aid effort.

Agricultural Science in South Asia

Dr. Bronk's resume of my past career activities suggests that I am a bit of an iterant and this is perhaps the situation with respect to South Asia. I first visited South Asia in 1950 and then annually during the past 10 years.

As we look at the agricultural development in South Asia, we might select India first as the best example of what has been done and what is underway. In pre-independence days, prior to 1947, India had a strong research program in certain fields. Much of this was in the theoretical areas, including excellent plant genetics and oil seeds research. We often fail to recognize that much of the U. S. sugar cane industry is based upon varieties that were developed through the excellent research of the Central Research Institute at Coimbatore.

Beginning with independence in 1947, the new Indian leadership began to take stock of what it must do to improve agricultural production and related education throughout the country. There was established the first University Education Commission in 1948 which studied education broadly, including that related to agriculture. It was in the report of this Commission that first mention was made of the importance of setting up "rural universities". In 1952, when the U. S. Foreign Aid Program was established, the technical cooperation mission in India also studied the need for research and education in Indian agriculture. As an outgrowth

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, at the Symposium on Science in South Asia, Rockefeller University, New York City

May 7, 1966

of this preliminary study there was developed a plan for a joint review in depth, by teams of Indians and Americans. In 1955 the first Joint Indo-American Team was appointed, composed of five leaders of Indian institutions, including the Council of Agricultural Research, the Agricultural Research Institute, and the State Ministry of Agriculture of West Bengal. I had the privilege of serving on this first team when we spent about three months in India on a wide-spread survey of research and education institutions. This followed a similar three-month visit of the Indian members of the team in the United States to study our national agricultural and education system. As an outgrowth of the review we developed specific recommendations--not massive and broad-sweeping ones--but about 118 precise proposals that we felt the government leaders in India could adopt as conditions would warrant.

In 1956 the Rockefeller Foundation was invited by the Government of India to implement some of the recommendations of the joint team, particularly with respect to establishing a post-graduate school at the Indian Agricultural Research Institute, and to initiate research to improve some of the cereal grains, particularly maize, sorghums, and millet. The Rockefeller Foundation, over the past 10 years, also has furnished guidance to the restructuring of the organization and program of the Indian Council of Agricultural Research, which only recently placed a scientist in its leadership position. Dr. B. P. Pal was named to the Directorship of the ICAR last month. In order to give follow-up attention to development of agricultural education and research centers, Technical Cooperation Mission, since 1956, has supported the request of

the Government of India for five U. S. land-grant institutions to furnish guidance to developing Indian colleges ofagriculture and veterinary schools.

The original emphasis in this effort was to improve the existing institutions in India, but after a few years increased attention was given to the establishment of new "agricultural universities". Involved in this program are the Universities of Illinois, Missouri, Tennessee, Kansas State and Ohio State. They are each giving attention to a specific region of India, for instance the University of Missouri is working in the Northeastern part of the country, in the counties of Assam, West Bengal and Bihar, the University of Illinois is working in North Central India, Ohio State in the Northwest, etc.

The post-graduate school was established in 1958 and by the time of the last convocation, almost a year ago, they had awarded 171 PhD. degrees and 400 Master of Science degrees. The enrollment in the school is about 400 annually, almost half of the students working toward their PH.D! degrees and the balance for their Masters.

The research on maize improvement was designated from the beginning to channel the support from the Indian Council of Agricultural Research into a coordinated nation-wide program that involved not only the government of India institutions but also the state ministries of agriculture and, as the agricultural universities emerged, the experiment stations of those universities. This formed a pattern that was

somewhat new and different in the Indian scheme of things but not too far different from what we have in the United States with the U. S. Department of Agriculture furnishing an overlay of support to and through the state agricultural experiment stations. The Rockefeller Foundation furnished only a small number of professional staff, and special efforts have been made tp encourage maximum participation of competent, young, Indian scientists so that they could take over leadership of the program as rapidly as possible. The other crop improvement research programs guided by the Rockefeller Foundation are concerned with sorghums, millets, and wheat. After four years of operation of the hybrid maize program, adapted hybrids were selected that are suited for Indian conditions from the Himalayas to the South Indian plateau. The hybrids are capable of increasing yields from 50 to 150 percent over the native varieties. Similar magnitudes of increase are obtained through use of the new varieties and hybrids of sorghums and millets that have been released, utilizing in this case some of the male sterile lines from the U. S. research programs.

The more recently initiated research on wheat improvement has been built initially on the short-strawed varieties developed in Mexico. They have the capability of utilizing high levels of fertilizers and of producing yields that are from 4 to 5 fold the yields of varieties now growing in India. In the past year steps have been taken to develop a similar national coordinated scheme for rice improvement with a basic

germ plasm materials primarily from Taiwan. The Taiwan varieties have the potential to increase yield to about 5000 to 7000 pounds per acre, as contrasted with normal Indian variety yields of around 1000 pounds per acre. If we put fertilizers on the normal Indian varieties, it is possible also to increase yields, but where we have the magnitude of demand for increased food supplies in India it seems sensible to utilize the maximum potential that may be available.

The agricultural universities have begun to emerge. In the Punjab, at Ludhiana is perhaps the most advanced of these universities that are coming up, among the seven that have been established. The Vice-Chancellor of this University is Mr. P. N. Thapar, who at one time was the Secretary in the Ministry of Agriculture of the Central Government. Another strong university is emerging in Uttar Pradesh, at the Tarai State farm. In 1957, when the Rockefeller Foundation was selecting locations for the regional research centers for the maize improvement scheme, the Tarai State farm was chosen because it was expected at that time that the State Government was thinking of establishing an agricultural university at that location. The maize improvement scheme has furnished the nucleus for the research station for the university.

There are agricultural universities coming into being in Orissa, Mysore, Andra Pradesh, Madhya Pradesh and Rajasthen. These are all in different stages of growth, and in different stages of growing pains, since these new ventures require a lot of guidance and leadership, locally as well as from the outside.

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As we look at the future of agricultural science and technology in India, we can see a new and effective pattern emerging for utilizing central government and state government resources. In the case of the maize program, the cooperating personnel from the Rockefeller Foundation have backed away from coordinating leadership and transferred this to Indian Government personnel. The Rockefeller Foundation staff in India are using the base that has been established at the Tarai Agricultural University to expand corn improvement research into other countries in South Asia and the Far East, including Thailand, Indonesia, Malaysia, Viet Nam, and the Philippines.

International leadership also is emerging in India, which may become the principal research center for improvement of surghums and millets for food use. The largest collection of surghums and millets in the world has been developed at the Indian Research Institute. This now is being assessed or evaluated for productivity not only in India but also in cooperative programs in Africa and in other areas of the world.

It is essential that we continue to improve the collaboration in agricultural science on a world-wide basis. We are taking steps at the moment, under AID support to enable the International Rice Research Institute to participate more in the National Coordinated Rice Improvement Scheme in India.

The agricultural universities in India have been established primarily as educational institutions and do not yet have the broad

competence that we have in the U. S. land grant universities. It will be necessary to incorporate a greater research component in the universities. We are reviewing this in cooperation with the Government of India personnel, and hope to expand research in these universities to increase production of the major food grains. This would involve strengthening the university capability to participate in the national coordinated crop improvement research programs.

In looking ahead to technical cooperation in agriculture, it would be desirable to plan national systems of research and development. There has been a tendency in past public and private technical assistance programs to select a U. S. institution to do a given job, in a given location, in a host country. There is a tendency for the cooperative effort to become isolated and somewhat provincially oriented. The importance in the United States of a land grant university was not only its integrated attention to education, research, and extension to serve a state or local area, but the greater impact of 58 of these institutions, independently established, but closely interrelated through their own efforts and through the coordinating research programs supported by the U. S. Department of Agriculture. This integration or network does not yet exist in India and should be developed in our cooperative efforts in the years ahead. This type of national or regional cooperation will be important in meeting immediate future needs.

India is depending heavily, in plans to meet future food needs, on the increased productivity of the Mexican wheats and the Taiwan rice varieties. These materials are coming from great distances, and there are many unknowns as to how they are going to behave in strange cropping environments. We never know how destructive new pests and diseases of such distant introductions may be. We again can take a lesson, however, from our experience in the United States with diseases in our major farm crops. As an example, in 1950, we first noticed a new strain of rust of wheat in this country. In 1953, we lost 65 percent of our durum wheat crop. The following year we lost 75 percent of it. These are the types of biological factors that we are confronting as we move vigorously to bring new crop materials into new environments, increase fertilizer applications, and confront unknown hazards to production. It is important that countries establish the kind of research system that can detect such hazards to production, and keep ahead of them.

As Dr. Revelle mentioned last evening, it is essential that more attention be given to land and water resources and use in India. This is a problem area in which outstanding progress is possible in the next few years. But, again, this must be addressed in concert with the magnitude of the possibilities and problems and not on a piecemeal, intermittent, haphazard basis.

In assessing India's food requirements and the production in recent years, we recognize the importance of an improved program of agricultural science and technology. In 1960 the production of food grains was at the level of about 78 million metric tons. It ranged up to 80 and 82 million tons up to 1963. In 1964 it was 88 million, but the estimate for this year is around 76. We do not have the same kind of an incline to the food grain production curve that we find in the population growth curve. The real question is whether or not this year's food shortage, which of course has been accentuated by the drought conditions, is an emergency or just a more serious segment of a chronic condition that must be remedied. In any event, India must develop the research and education institutional base that in the years ahead will provide the innovations for agricultural production and support growth of output of a rate of 5 to 6 percent each year and keep pace with population growth and nutritional needs. This is one of the more significant problems for Indian leadership. One of my good friends in the Indian Agricultural Research Institute, when I was in the country in February, pointed out that the modernization and change in traditional agriculture is a problem not of the illiterate but of the literate. And his point was that most farmers are willing to adopt new materials and methods from applied science and technology but the real difficulty is convincing the administrative and political leadership of government and the budget-makers that it is wise to invest in the long-range efforts in science

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and technology rather then to perpetuate a series of crash or action programs. Short-range or crash efforts will not add up to the kinds of growth required in food deficit countries such as India, with current food shortages and expanding needs in the years ahead.

In closing, I might just say a few words about Pakistan. One of the best agricultural research institutes in South Asia at the time of Indian independence was in the Punjab, at Lyallpur, in the major breadbasket of what was formerly India. In recent reviews of progress in agricultural development throughout the world, Pakistan rates high. As Dr. Reveile pointed out last night, the growth rate has been at the level of about 7 percent annually over the last four or five years. If we look at how this was achieved, however, we find that much of the added output came from bringing in new land and water resources and by utilizing available technology, including improved irrigation practices, better crop varieties, and increased amounts of fertilizers. In talking with U. S. A.I.D. staff members and Government of Pakistan agriculturists in Karachi in February, they pointed out very frankly that they were running out of resources or new inputs and increasing production in the years ahead would depend upon the availability of new knowledge. As they put it, "We're running out of 'intuitions' as to what to do; we could go out heretofore and say throw on a bag of fertilizer; now the question is, do we throw on another bag of fertilizer or do we do something else?" Pakistan must give added attention to science and technology if it is going to keep up the pace of agricultural

growth that it has demonstrated so ably up until now. Pakistan, as India, is looking to the Mexican wheat varieties and to the Taiwan rice varieties as a part of the major base of technical inputs to improve agricultural production. Adequate attention should be given to the development of the kind of institutional base within Pakistan that is necessary for sustained research and adaptive studies for continual agricultural growth and development. No nation should be dependent upon outside resources for its agricultural science and technology over any extended period of time. The international Rice Research Institute in the Philippines will make a real contribution over the next five or ten years, and the resources from the Mexican wheat program also will be most helpfut over the short run. It is extremely important that Bakistan, as well as India, move vigorously to establish the kind of an institutional base, the national system of agricultural research and education, that will enable it to be fully self-sufficient in expanding agricultural growth in the years ahead.

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STATEMENT OF
DR. A. H. MOSEMAN, ASSISTANT ADMINISTRATOR
FOR TECHNICAL COOPERATION AND RESEARCH
AGENCY FOR INTERNATIONAL DEVELOPMENT
BEFORE THE U.S. SENATE COMMITTEE ON COMMERCE

May 16, 1966

Mr. Chairman,

I appreciate this opportunity to appear before your committee to discuss the significance to our foreign aid efforts of S.2720, a bill to authorize the Secretary of the Interior to develop practicable and economic means for the production by the commercial fishing industry of fish protein concentrate.

The Agency for International Development is deeply concerned about the problem of protein malnutrition in many areas of the world. In a message to A.I.D. field missions in July, 1965, Administrator David Bell stated:

> "A.I.D. health personnel are now of the view that correcting serious protein deficiencies of pre-school children would make a greater contribution to development than any other health measures -- malaria eradication, sanitation, and water supply not excluded. It is clear that Food for Peace donations alone cannot solve this problem; and that coordinated efforts by our agricultural, health, industry, and community development programs will be required if progress is to be made."

Of special concern is the level of protein in diets of infants, particularly in the weaning period, and children under six years of age.

Malnutrition at this age level not only causes death for millions of children but may cause irreversible retardation of mental and physical development of those who survive. The shortened life, decreased resistance to infectious diseases, impaired physical and mental development, and generally decreased production capability may seriously hamper social and economic development.

In the past 12 months, the Agency for International Development has taken special action to strengthen our cooperative efforts in nutrition. A Nutrition Branch has been established in our Office of Technical Cooperation and Research. Dr. Max Milner, formerly with UNICEF as Senior Food Technologist, joined the Agency on February 1, 1966, to furnish technical leadership to field programs in nutrition and to guide an expanding program of research.

It is our conviction that the world's protein deficit is of such magnitude that all feasible approaches and resources necessary to achieve its solution must be perfected and mobilized. The following activities are included in the A.I.D. program designed to improve nutrition levels in developing countries:

1. Improvement of production of animal proteins, including dairy products, beef, swine, and poultry.

2. Development of formulations and processing technology for economical grain-based, protein-supplemented foods, suitable for family use and as supplementary foods for young children. These mixtures, which are now being readied for shipment and distribution under the Food for Peace

program in several countries including India, now utilize wheat and corn as the cereal components and defatted soy flour and dry skim milk as the protein supplements. When fish protein concentrate of suitable quality, and in adequate supply is available at a reasonable cost, it will be an important added resource for use in these types of food fortification programs.

3. Crop breeding research programs, aimed at upgrading by genetic means the nutritive value of major food and feed grains, including corn, sorghums, and wheat. This effort has been given strong impetus by recent research at Purdue University where it has been conclusively shown that two genes, known as "floury" and "opaque-2", can be introduced into almost all types of corn, producing a doubling of the amino acid lysine as well as significant increases in tryptophane, methionine and cystine. The result is a dramatic increase in the nutritive value of the cereal protein component to a level comparable to that in animal proteins. The replacement of standard varieties of corn, sorghums, and wheat with strains having protein of the potentially higher quality would have a profound effect on the nutritional status of many cereal-eating populations. It is clear, however, that the full impact of this research will not be achieved for a number of years to come.

4. Food processing studies, financed by A.I.D. and conducted by the U.S. Department of Agriculture, to improve the utilization for food purposes the oilseed protein resources from cottonseed, peanuts, and soybeans. Many tropical countries where protein malnutrition is widespread, have abundant quantities of such materials which are at present largely diverted to fertilizer use or to animal feeding.

5. Introduction, expanded cultivation and genetic improvement of grain legumes (peas, beans, pulses) which are the traditional and accepted protein dietary mainstays of many less developed countries, including India and countries in Africa. Efforts are under way also to introduce soybean culture in a number of less developed countries, for use in processed, protein-rich foods.

6. Supplementation of wheat foods with the commercially available amino acid lysine, to improve their nutritive value. We are planning a pilot study in a wheat-eating country now receiving major inputs of U.S. PL 480 wheat, to determine the extent of nutritional improvement and increased efficiency of utilization that might be achieved from wheats supplemented with lysine.

The foregoing examples furnish some evidence of the efforts being made by the Agency for International Development to increase world supplies of proteins. They reflect our real concern and the variety of resources we are exploring.

The U.S. Department of Interior's new publication, Fishing Leaflet 584, entitled "Marine Protein Concentrate" provides a clear and concise description of the process and the product developed during the past two years at the Bureau of Commercial Fisheries Technological Laboratory in College Park, Maryland. The blandness of the product, its apparent freedom from toxic factors, and its high protein biological value are most impressive. It is to be hoped that the projections of costs will prevail up to larger industrial levels of processing.

We are hopeful that there may be favorable action by the Food and Drug Administration on this product which not only will permit use of a domestically processed product for food use at home and abroad but also will enable the Agency for International Development to consider more effective programs of technical guidance and related assistance to food-needy countries which have adequate fish resources for establishing local fish protein concentrate industries.

It is recognized that while significant progress has been made in producing an acceptable fish protein concentrate much remains to be done. The present isopropyl alcohol deodorizing and defatting process and its product represent only a beginning toward an array of processes and products which appear to be feasible. The isopropyl alcohol product processed from whole red hake, as described in Fishing Leaflet 584, provides only a limited demonstration of the broader potentialities of fish protein concentrate. Since its major use will be as a protein supplement in staple foods, more evidence is needed of its compatibility as a food additive, whether it improves or otherwise favorably modifies staple foods. It has been correctly pointed out that addition to common foods of a material which improves nutritional quality alone will not insure its acceptance by undernourished populations.

The present BCF process should be tested with many other species of fish, particularly those available to less developed countries which are confronted with protein deficiency problems.

The original range of investigations to explore additional processing approaches to prepare useful fish protein concentrates, which were postponed in favor of immediate development of the isopropyl alcohol technique, might

usefully be pursued. Preservation by enzyme processing and production of powders of improved color, stability and solubility should be studied. The United Nations Agencies have frequently pointed to the fact that in some societies a completely bland, taste-free product is not required and indeed may not be desired. Sanitary, nutritionally safe, and acceptable products retaining fish flavor, suitable for a variety of food cultural patterns, should be developed, particularly if the costs of such products would be less than the present material.

New products such as fish protein concentrate may not become widely accepted without careful investigations to determine feasible approaches to their introduction into various foods and into different cultural patterns. Such studies should be concerned also with assessment of effective techniques for marketing and promotion.

Much work remains to be done in examining food habits and preferences of the various cultures or ethnic groups which might benefit by supplementation of their foods with fish protein concentrate. The development of indigenous recipes using various combinations of fish protein concentrate should be undertaken as an integral part of such studies.

Mr. Chairman, the Agency for International Development is deeply interested in the further perfection and utilization of fish protein concentrate materials and we regard the expanded research and development activities that would be made possible under S. 2720 as of direct and positive benefit to our foreign aid efforts.

Mr. Chairman, I have with me Dr. Max Milner, Chief of the Nutrition Branch of the Office of Technical Cooperation and Research who is directly responsible for guiding A.I.D.'s work in the nutrition field.

We would be glad to respond to any questions the Committee may have.

National Systems of Science and Technology for Agricultural Development

I welcome this opportunity to exchange views and to reach better understandings of technical assistance for agricultural development. John Blackmore did not warn me, however, that this paper would be subjected to such special surgery as our base for discussions for the day.

It is most appropriate for this group to give serious consideration to joint efforts in international agricultural improvement. The Land-Grant Institutions have a long and distinguished record of collaboration, among themselves, and with the U.S. Department of Agriculture, in transforming a nation's agriculture. This task must be repeated, not once but many times over, and not through an evolutionary process but within an international atmosphere of urgency. We cannot casually learn as we go; we must apply the best and most effective resources and techniques we can muster to energize agriculture to double and treble output in many environments before the end of this century.

The broad objective of the U.S. foreign assistance program is to accelerate economic and social progress, to build strength and stability into developing nations. The need to equalize opportunities

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the Annual Conference, University Directors of International Agricultural Programs, Student Center, St. Paul Campus, University of Minnesota, Minneapolis, Minnesota

June 9, 1966

and levels of living for individuals is readily apparent when we compare the annual per capita income of less than $150 in many developing countries with the $2,700 estimated for the United States in 1965.

Today's less developed countries have been classed as "poor, tropical, and agricultural," with 75 percent or more of their people living on the land. Total world food production has increased gradually over the past decade; but on a per capita basis it is declining in most of the LDC's. In a few countries, such as India, where a short monsoon in 1965 poses the threat of famine this year, there are uncertainties also in the years ahead. With 12 million more people annually, India will add as many more by 1970 as Mexico has today.

Improved health services that cut infant mortality and death rates, together with increased incomes that cause demands for food to rise, will contribute to the future spread between population growth and food supplies. Many countries, with a population growth of 2.5 to 4.0 percent annually, will double their present numbers by the end of this century.

The population problem transcends the question of hunger and must be assessed not in terms of numbers but rather in terms of healthy, well educated children, and healthy mothers. To achieve this objective, it is essential that countries with current and potential food deficits face up to the need for effective family planning as well as for expanded food production programs.

The attitudes toward food and population can no longer float between superficial limits of optimism and pessimism. It is time for

realism, to consider critically the tools and techniques required to get the agricultural sector going.

Current Assessments of International Agriculture

The Food for Freedom program announced by President Johnson in his message to Congress in February, makes clear the intent of the United States to furnish food aid that is geared to maximum self-help by recipient countries in improving their agricultural sector. We no longer consider such food aid as a disposal of surpluses since for many agricultural commodities production is now closely geared to annual consumption and minimum carryover stocks.

It is estimated that in 1966 the food deficit in the developing countries will total about 16 million metric tons. This will increase to 42 million metric tons in 1975 and to 88 million metric tons in 1985, assuming that present food production trends continue, that population growth will be at the median level of the UN projections, and that there will be only a modest increase in per capita food consumption. The estimated 42 million ton gap ten years hence exceeds the total of one annual U.S. wheat crop, and the 88 million ton shortfall in 1985 will be beyond the U.S. cropping capacity, even if we were to put back into production the 55 to 60 million acres now in reserve. It is abundantly clear that the U.S. cannot feed the world.

As we chart the course ahead to achieve greater self-sufficiency in the currently food-deficit nations, we might consider three distinct but interrelated phases: 1) the short run period of the next decade or more

with heavy dependence on supplies from food surplus nations; 2) increasing emphasis on adaptive research to develop, test and apply new materials and production practices to upgrade inefficient traditional agriculture; and 3) the building of the indigenous base of science and technology that is essential to furnish a sustained flow of innovations for continued growth in production to meet the needs in the years ahead.

The proposed "phases" do not imply deferred attention to actions two and three. There already has been too much reliance on crash efforts and the hope that a series of short term panaceas will add up to long term solutions. Ten years is not an excessive lead time for the adaptive research and testing to install dependable innovations. And twenty years is a short period in which to build a coordinated nation-wide research and education institutional base, with trained personnel and the organizational and budgetary stability essential for effective operation.

Realigning Foreign Aid for Agriculture

The past cooperative technical assistance efforts in agriculture, designed primarily "to transfer U.S. know-how", have made it increasingly clear that most materials from the temperate zone are not readily transferable to tropical or sub-tropical environments. Similarly, U.S. production practices are not well suited to the physical and economic conditions of small-farm agriculture. Although some striking progress has been made through the energies of outstanding extension or rural development specialists, such as Ben Ferguson in East Pakistan, farmers in most traditional agricultural

societies already are obtaining nearly maximum returns from the resources at hand. The reshuffling of available materials and knowledge may achieve limited and short-term progress but will not provide for sustained growth.

The agricultural advisors in one Asian country that has had an annual growth rate of about 5 percent over the past five years, recently stated, "We need new inputs -- and can no longer depend merely on intuition. So long as we could say 'throw on a bag of fertilizer' we got along well. Now the question is whether we suggest throwing on another bag of fertilizer, or consider doing something else."

Much of the past cooperation in agricultural development has been scattered and fragmented, with individual specialists assigned in soil science, poultry production, dairy manufacturing, and similar narrowly defined fields. Such cooperation is of limited value in most countries because of the lack of a technological matrix or of a science and technology infrastructure in which to imbed innovations. Most of the college contracts involving the land-grant institutions have not utilized the special strength of these organizations with their coordinated research, education, and extension components. Instead, they have called for assistance in developing an educational program, or an extension service, or a department of agricultural economics, or other specialized sectors.

Past efforts have been helpful, however, and much has been accomplished through the accumulated technical assistance activities in many areas of the world. We can point to substantial numbers of trained

personnel, to a variety of strengthened institutions, and to a greater appreciation of the kinds of problems involved in agricultural development. There has been marked progress in agricultural growth in many of the developing countries, although a considerable part of such growth has resulted from new land and new water sources rather than from enhanced productivity of existing arable lands.

The Role of Science and Technology

There has been an increasing awareness in recent years of the need for new technical inputs and new production change agents to make agriculture move in the developing countries.

Dr. T. W. Schultz, Professor of Economics of the University of Chicago (1963), has consistently emphasized the importance of profitable new agricultural inputs, including the machines, fertilizers, pest control chemicals, and genetic attributes of plants and animals that combine to increase yields by threefold or more when properly adapted to specific farm environments.

Dr. David Hopper, Agricultural Economist with the Rockefeller Foundation in India, who has spent many years in Asia with the Ford Foundation and other organizations, assessed the Comilla project in East Pakistan in a report in August of 1964. He concluded that changes in production practices and in irrigation in recent years had made the poor farmers better but had been of limited benefit to the already good farmers. Dr. Hopper's judgment was that "the factors limiting output in the future will be the shortage of technical knowledge and the low quality of many

inputs, especially crop varieties. As yet (1964), there are no research programs in East Pakistan that hold promise of an eventual solution to these shortages."

Dr. F. F. Hill, Vice President in charge of International programs of the Ford Foundation from 1955 through 1965, at a meeting of the American Farm Economics Association in New York in December 1965, stated that "Countries threatened by food crises need emergency research teams from the U. S. for at least the next ten years." He proposed that these agricultural research or technology teams should guide special and vigorous efforts to speed up the development, testing, and diffusion of substantially improved production technology for food crops. Dr. Hill's assessment is based on ten years of experience in guiding the resources of the largest private foundation of the United States in a variety of efforts, primarily in extension and community development, to accelerate economic development abroad.

Dr. Charles M. Hardin, Director of the International Agricultural Center, University of California at Davis (1966), questions the continuing emphasis on action programs "designed to galvanize people into action" and the reliance on skilled operators or activists to help set up credit institutions, improve transportation, provide better marketing facilities, and modernize the distribution of improved seeds, fertilizers, and plant protection equipment and materials. Dr. Hardin calls attention to the lack of success in increasing agricultural output through such action-oriented

efforts in the past and suggests that this continued "misdirection of development policy roots in a evident failure to understand the U.S. experience". He emphasizes that while a great many favorable factors have contributed to the amazing growth in agricultural efficiency in the United States, one central thing we have done is to build on agricultural science and this is probably the most repeatable and adaptable of our experience. Dr. Hardin states that while the prevalent idea is to transplant "American know-how", the hard central core of success of such "know-how" is institutionalized science and this is what must be exported and helped to grow overseas.

It is generally recognized that the productivity of the American farmer is not equalled elsewhere in the world. It is not generally recognized, however, that the American farmer has the constant and sturdy backstopping of a system of agricultural science and technology that is not matched in any other nation. Most major hazards to agricultural production in the United States that can be controlled by man have been overcome and new threats or potential inhibitors have been short-lived. Those who share Dr. Hardin's views would perhaps agree that rather than export a "bread and butter corps" to aid agricultural development abroad we might consider establishing a few bakeries and creameries in the cooperating countries.

The views of Drs. Schultz, Hopper, Hill, and Hardin have special significance since all of these men are leading economists and social scientists with extensive experience in agricultural development in the

U.S. as well as abroad. Their identification of the importance of biological and physical inputs from agricultural science does not, of course, minimize the importance of attention to other essential factors in the agricultural sector.

Dr. Arthur T. Mosher, in his new book, "Getting Agriculture Moving", identifies five "essentials" or special requirements for agricultural development, as:

Markets for farm products

Constantly changing technology

Local availability of supplies and equipment

Production incentives for farmers

Transportation

He emphasizes that the order of listing has no significance with respect to his assessment of the importance of each.

In addition to the "essentials", Dr. Mosher reviews five "accelerators" as:

Education for development

Production credit

Group action by farmers

Improving and expanding agricultural land

National planning for agricultural development

The focus on systems of science and technology as the basic issue for our discussions today is a purposeful selection of only one of

Dr. Mosher's major factors or "essentials" in agricultural development, (constantly changing technology). If we attempt to address all factors we continue to get lost in the maze of thinking that everything must be done concurrently -- and we may again wind up picking the easiest and most universally understood elements as those in which to invest our resources and place our hopes. We have considerable experience in building storage facilities, fertilizer and other chemical plants, and transportation systems. Price policies are decided by relatively few people in key leadership positions.

These "essentials" will take on added meaning as new materials and production practices emerge from well organized and well oriented national research systems. Production credit will then have greater relevance, as will local availability of fertilizers, pesticides, improved seeds, and equipment; price incentives will have new meaning when farmers have something to respond <u>with</u> as well as to respond <u>to</u>; and transportation, storage and marketing facilities will be more essential as farmers have more to sell. Studies in production economics, and on national and international markets, will take on new perspectives as innovations alter production efficiencies and help guide judgments on the degree of self-sufficiency of food production versus the alternative of a strong base of commercial agriculture with exportable cash crops and larger imports of food products.

Institutionalized Agricultural Science and National Development

Earlier this year a distinguished Indian agricultural scientist suggested that the major problem in modernizing traditional agriculture rests not with the illiterate but with the literate. He pointed out that farmers respond to dependable, profitable innovations but it is the political and administrative leadership that fails to understand the significance of science and technology in furnishing the base for agricultural growth and so fails to allocate resources for developing scientific capability.

It is, of course, a paradox that some countries with recently gained political freedom have not recognized the significance of the agricultural sector to their national and international strength and stature and have accepted a "science and technology colonialism" in their agricultural development. Some nations today are dependent on others not only for a portion of their food supplies, but also for the improved seeds, fertilizers and pesticides for domestic production of foods, and in certain cases are becoming increasingly dependent for the science and technology to maintain even currently inadequate production. An unproductive agriculture not only inhibits economic and social growth of a developing nation, but contributes also to political instability. The decline of Nikita Kruschev in the U.S.S.R. was accelerated by the failure of his "new lands" projects. A second, more recent lesson in the politics of hunger is presented by the loss of power of Kwame Nkrumah in Ghana, where the growing food lines contributed to public dissatisfactions.

The participation of new, developing countries in international agricultural exchange is, of course, to be encouraged and it is recognized that approximately one-half of our U.S. agricultural income today is derived from materials we introduced from abroad. However, the continuing reliance on international resources for the basic scientific and technological underpinning of the agricultural sector of a nation's economy is a matter that deserves serious attention of a nation's leadership. Continued agricultural growth requires a sustained flow of new inputs. This cannot be achieved through a series of infusions or transplants of segments of science from abroad. Indigenous institutions must be established to furnish this sustaining agricultural science and technology.

Because of its economic, social, and political significance, a nation cannot delegate responsibility for agriculture as an incidental task to be handled by the states or local institutions. This must be kept in mind as we help to build strength into the agricultural research and

The U.S. institutional pattern for agricultural science and technology includes a strong national responsibility in the U.S. Department of Agriculture for research to improve the production of major crops and livestock, and also on a variety of economic problems. The U.S.D.A. and the State Agricultural Experiment Stations collaborate on many major problems of regional concern. The states, with their branch stations, continue the outreach into the micro-environments of local communities. The U.S. farmer is, therefore, served by a system of science and technology that is unique not only in responsiveness to precise problems and needs, but also in efficiency in combining public resources at the national, state, and local level.

Adaptations from U.S. Experience

As we assist cooperating countries to establish national systems of agricultural science and technology, it is essential that we recognize the significance of the relevant functions, including (a) the development of new materials and knowledge, (b) the transfer of innovations into use on the land, and (c) the building of human resources to perpetuate the evolution, transmission, and use of new technology. It is equally important, however, that we recognize the insignificance of the precise form of organization. Institutions may perform effectively under a variety of patterns of governing bodies. Insistence on the organizational structure characteristic of a U.S.D.A. agency, or of the complete and integrated research, education, and extension combination of a U.S. land-grant college may well be detrimental

in a country where research is the responsibility of the Ministry of Agriculture, education ties to the Ministry of Education, and extension functions may be handled by a variety of organizations. In Colombia, for example, different types of extension services are handled by twenty-six organizations concerned with some aspect of the agricultural sector.

The assessment of U.S. experience to guide the development of institutional patterns in the developing nations is difficult because the U.S. pattern has changed constantly, with substantial modifications during the past two decades. A scanning of the spectrum of evolution of our scientific agriculture would, however, be helpful in identifying experience and institutional potentials that may be most "repeatable or adaptable".

The evolution of progress in corn improvement in the United States furnishes some interesting guidelines. Dr. T. W. Schultz (1963) noted that the high pay-off agricultural inputs in the U.S. have seldom been furnished by our most progressive farmers, and pointed out that the corn yield tests of 1904 - 1915, in which leading Iowa farmers tested their best materials and practices on 75,000 field plots, made no impact on the state average yields. The yields were 32.4 bushels in the 1896 to 1905 period and averaged 33.0 bushels during 1913 to 1915.

The efforts of individual scientists, even those most competent, were relatively insignificant in making any real impact in improving corn production. The many classical contributions to our knowledge of genetics and "heterosis" or hybrid vigor by leading genetists of the U.S.D.A. and

the universities during the two or three decades up to 1920 did not change farm practices or yields. Dr. H. K. Hayes, Professor Emeritus and former head of the Division of Agronomy and Plant Genetics of the University of Minnesota, who was a prime leader in corn genetics research during this period, has suggested that the real impetus to corn improvement dates from the establishment of the cooperative federal-state research program under the Purnell Act in 1923, with coordinating leadership furnished by the late Dr. F. D. Richey of the U.S.D.A. Within ten years time, by 1933, adapted hybrids suited for wide areas of the corn belt were being used and this major breakthrough in improving crop yielding capacity stimulated the establishment of similar cooperative research efforts with other crops. Additional coordinated U.S.D.A.-state agricultural experiment station projects, to give regional and national research attention to improvement of wheat, small grains and forages, and to other agricultural problem areas, were undertaken in the late 1920's and the 1930's.

It was evident after a few years that the corn hybrids adapted to the corn belt were not suited for the southern and southeastern agricultural areas of the U.S. A special regional corn improvement project, again guided by Dr. Richey, with headquarters at the Tennessee agricultural experiment station and with U.S.D.A. personnel located at the state experiment stations in North Carolina, Georgia, Mississippi, and Louisiana soon produced the "Dixie" series of hybrids that helped to revolutionize agricultural practice in the southeastern U.S.

The emphasis in the 1930s was shifted increasingly toward interdisciplinary research, with the Bureau of Plant Industry re-organizing to focus attention on specific commodity improvement programs in which the talents of plant genetists, plant pathologists, physiologists, and other scientific disciplines were combined. The merging of federal soils and agricultural engineering research units into the Bureau of Plant Industry, Soils and Agricultural Engineering in 1942 produced additional emphasis on soil, plant and cultural practice interactions. The adaptive research initiated at North Carolina State College in the early 1940s in cooperation with the U.S.D.A. to combine locally adapted corn hybrids, various plant populations, and soil fertility management, was one of the early demonstrations of the importance of such interactions in American crop production.

The closely coordinated federal-state cooperation has prevailed in the U.S. since 1923, but the ties have been less close in recent years. One of the early diversions from this pattern came in the mid-1930s when a number of private seed companies were established, employing state or federal scientists to conduct adaptive research to develop corn hybrids suited to the specific environments in corn belt states. This shift toward applied research by private companies, and their increasing participation in salesmanship or extension, caused state and federal scientists to shift attention increasingly to background or basic research in corn improvement.

The passage of the Research and Marketing Act of 1946, providing funds directly to the states to initiate regional projects, had the effect

of further dissolving the close federal-state partnership in regional, problem-oriented research programs. The subsequent availability, in the 1950's, of federal funds for grants to individual projects and to individual scientists, under the NSF, NIH, and NASA, resulted in a still further dispersal of interests of the scientific talent related to agriculture, and accelerated attention to fundamental or "opportunity-oriented" research. This has been described as research that develops answers for which problems are then sought. In our highly industrialized society such spawning of new knowledge is justifiable since the shelf life of such innovative ideas or materials is usually only two or three years. This individual "opportunity-oriented" research has little relevance, however, in a society that lacks a technological infrastructure.

The turning of many agricultural scientists, especially in the university community, toward such project-oriented studies has occurred during a period of public and administrative apathy toward agricultural research, with our domestic agriculture crowded with commodity surpluses. The combination of events or factors during the past 15 years has tended to reduce the manpower in the states and federal agencies concerned with problem-oriented agricultural science and technology. And much of the U. S. institutionalized science related to agriculture has moved beyond the period when federal and state resources were highly integrated to combine the talents of many disciplines for resolution of critical problems or inhibitors in agricultural production.

In extracting U.S. experience and institutional alignments applicable to developing nations, it is doubtful whether the inter-change of ideas by farmers will be especially productive, nor will the efforts of individual and isolated scientists that characterized the U.S. experience up to the 1920s. It is likewise questionable whether the use of resources for individual and isolated efforts, characteristic of present U.S. project grant support for narrow fields or disciplines, will produce effective change agents in traditional agriculture.

At present there is little or no agricultural research and development conducted by the private sector in most developing countries, although this should be encouraged.

While it is difficult to sort out any single most effective institutional base or pattern of organization, we have considerable evidence that the system of applied science and technology for agricultural development in the United States built around the network of the 58 land-grant institutions, with the overlay of U.S.D.A. support in the form of professional staff and operating funds, was a major factor in the rapid advance in our agricultural progress during the past three decades. This system has been highly responsive to needs of our agricultural industry. A number of emergency problems were quickly headed off by this system, including the outbreak of the black shank disease of tobacco in the Carolinas and Kentucky, the spread of the poisonous weed Halogeton in western rangelands, the suppression of the outbreak of wheat smut in the Pacific Northwest, the threat of the Mexican fruit fly, and many similar hazards to U.S. agriculture.

Emerging Patterns of Agricultural Development Systems

Technical assistance efforts are helping to build the basic structure for national institutionalized science systems in a number of countries. In India, the Indian Council for Agricultural Research has applied its support increasingly in the past 10 years to "National Coordinated Research Schemes" for improving production of maize, sorghums, millets, wheat, and rice. The research is inter-disciplinary, applied or problem-oriented, and tied into research stations of the state agricultural universities wherever this is possible. The Rockefeller Foundation is supplying cooperative professional guidance and some financial aid for equipment and supplies for the coordinated research schemes.

The U.S. Land-Grant Universities of Missouri, Illinois, Tennessee, Ohio State and Kansas State, under A.I.D. contracts, are furnishing assistance in establishing agricultural universities in seven states of India. The Government of India recognizes the potential value of such institutions and has decided that one agricultural university should be established in each state. The Indian Education Commission, composed of leading educators from India, Britain and the U.S., in its report in 1965, endorsed this goal and proposed that some of the larger Indian states should have two such universities, with a total of 20 for the country.

There is still need in India for clarification of responsibility for research and extension at the state level, to strengthen the research component, to improve the linkage with the ICAR schemes, and to tie more

effectively into the extension and community development organizations to feed new research inputs into the villages. The basic pattern is well established; however, it has demonstrated its suitability for Indian conditions, and is ready to grow in effectiveness as financial and human resources are available.

The Colombian Institute of Agriculture, built on the base of cooperative research supported by the Rockefeller Foundation since 1950, is taking shape as a national system for research, education and extension. The Ministry of Agriculture and the National University are collaborating, with the University's Agronomy Faculties at Bogota, Palmyra, and Medellin principal centers for education and research. The Ministry of Agriculture experiment station at Tibaitata is the principal headquarters, and research centers at ten other locations characteristic of local environments provide an effective network for this developing national system.

The Rockefeller Foundation support for research; Ford and Kellogg Foundation assistance for extension, economics, and graduate teaching; and A.I.D. support through the contract with the University of Nebraska for strengthening the education program furnishes a "pluralistic" or informal consortium effort that should make rapid progress.

The National Institute for Agricultural Research and the National School of Agriculture with its graduate school in Mexico will be associated in the agricultural center at Chapingo, with support from the Ford and Rockefeller Foundations, the Inter-American Development Bank, and A.I.D. The nation-wide program of research aided by the Rockefeller

Foundation since 1943, as in the case of Colombia and India, furnishes the "National System" focus in Mexico. Iowa State University is participating in the graduate school development at Chapingo, with Ford Foundation support. Further attention will be needed for effective linkage of education, research and extension in Mexico but this integration is in process.

In Peru, the Agrarian University and the Agricultural Research and Extension Service of the Ministry of Agriculture, with A.I.D. support through the North Carolina State University, and with assistance also through the Rockefeller and Ford Foundations, and UN Agencies are furnishing the nucleus for a strong national system for agricultural development. Brazil and Chile also have important elements of strength upon which institutionalized science and education could be built into national systems.

Nigeria, with cooperation from the Land-Grant Universities of Michigan State, Kansas State and Wisconsin, is building regional strength and with added development of research capability and coordinating leadership at the national level would have an outstanding national system.

In Asia, excellent opportunities exist for evolution of effective national programs of science and education in the Philippines, Thailand and Korea.

The foregoing list of countries is not exclusive and there are many others that have attractive potentials for strong national agricultural development systems.

U. S. Institutional Resources for Cooperative Development of Indigenous Agricultural Improvement Systems

U. S. resources should preferably be applied in cooperative assistance programs in a manner that will draw on the background of specific experience that is most applicable to the requirements of the developing countries. The U.S.D.A., with its long term attention to the introduction and adaptation of new materials and techniques to a wide range of agricultural conditions, and its effective role of coordinating leadership in a variety of nation-wide cooperative research efforts, is gaining experience abroad in directing regional research projects for improvement of corn and sorghum production in Africa, and for improvement of grain legumes in Asia.

The Rockefeller Foundation has had more than 20 years of experience in research to improve production of the major food crops in Latin America and for a shorter time in Asia and Africa. These programs have an orientation similar to that of the U.S.D.A. in that they are nation-wide in scope, multi-disciplinary in approach, and involve extensive international inter-change of materials. Cooperative work of the Rockefeller Foundation has furnished the nucleus for development of the National Agricultural Institute at Chapingo, Mexico; the Colombian Agricultural Institute with headquarters at Bogota; the National Agricultural Research Institute in Chile with its excellent experiment station facilities at Santiago, Temuco, and Chillan; and has helped to strengthen the organization and programs of the Indian Council of Agricultural Research, the Indian Agricultural Research Institute with its postgraduate school, and agricultural university development in India.

The Ford Foundation, which in earlier years focused heavily on agricultural extension and community development, has given increased attention to crop improvement research with nationally oriented cooperative programs under way in Pakistan on wheat and rice production.

The Ford and Rockefeller Foundations are collaborating in the development of additional international agricultural development resource centers, with an Institute for Tropical Agriculture in process of development in Nigeria along the same pattern as the International Rice Research Institute that was established in 1962 in the Philippines.

The U.S.D.A., the Ford and Rockefeller Foundations programs, and the International Rice Research Institute all have the type of experience required for furnishing guidance to the "national" components of agricultural science and technology systems.

The land-grant universities are participating in a large number of contracts for institutional development abroad. In most instances, however, we are not drawing upon the research capabilities of these universities, one of their major strengths in contributing to U.S. agricultural development. Further attention should be given to the incorporation of a research component, to the combination of research and education functions, and to the linkage into the extension or community development organizations within the localities in which these universities are cooperating. Greater recognition also should be given to the informal linkage of the cooperating indigenous institutions into a national system, involving cooperation not only with other state or regional

research and education centers but also with the central government's agricultural development institutions.

In addition to the specific "university development" contracts, the U.S. land-grant universities are furnishing leadership to selected broad international programs, such as the University of Wisconsin land tenure center, the North Carolina State project in soil testing, and the Oregon State University project concerned with weed control. These three cooperative projects are operating initially in Latin America, but as experience is gained they may be extended to other parts of the world.

Less progress has been made in establishing centers of excellence for livestock improvement and for animal health, but a number of such points of strength are beginning to emerge in Brazil, Peru, Colombia, Mexico and Nigeria. Such animal improvement centers should be strengthened, with a more effective linkage to selected livestock research institutions in the United States.

New Material Resources for Agricultural Development

was incorporated into the short strawed "Mexican wheats" at the CIANO experiment station at Ciudad Obregon, Sonora, Mexico, where it was found that some of these varieties are non-photosensitive to day length and, therefore, adapted for growing over a wide range of latitudes, from the equator to 45 degrees north or south. They are capable of utilizing up to 120 pounds of nitrogen per acre, to produce yields of 100 bushels or more under irrigation in Mexico, the Near East countries, Pakistan, and India. This yield potential compares with the current National average production of 12 to 20 bushels per acre in many of these countries.

The collection of 12,000 lines of maize germ plasm in Latin America has furnished the base for the new hybrids and synthetic varieties developed in the Latin American cooperative research program and in the similar cooperative research in Asia, with headquarters in India that has extended into Thailand, Malaysia, Indonesia, Vietnam, and the Philippines.

The sorghums and millets collection in India, which was built around the U.S.D.A. collection but now includes substantial additional materials from Africa and India, may well make South Asia the principal research center for improvement of these crops in the future.

The International Rice Research Institute, an autonomous organization at Los Banos, the Philippines, that was established through the joint efforts of the Ford Foundation and the Rockefeller Foundation, provides the principal resource for materials and technological leadership for interdisciplinary scientific attention to the improvement of rice production in Asia.

The establishment of these new regional or international resource centers for agricultural improvement in the tropical or sub-tropical environments more characteristic of the conditions in the less developed countries is an important progressive step of the past five years. Agriculturists concerned with technical assistance activities should be made aware of these growing resources.

Adaptive Research

The "international centers" do not minimize the need for strong national systems of institutionalized science that adapt introduced materials and techniques to specific environments. Foreign introductions into U.S. agriculture have furnished the base for much of our agricultural industry but it was not until we applied the intensified research efforts of the U.S.D.A. and the state agricultural experiment stations that we developed our present high levels of productivity.

The rapid introduction of new plant varieties over widespread acreages enhances the risk of loss from new forms of disease or from indigenous insect pests. The U.S. experience with race 15B of stem rust of wheat furnishes a clear object lesson. This new virulent race or rust was first noticed in farmers' fields in 1950. In 1953 and 1954, the widespread disease wiped out 60 and 75 percent of the nation's durum wheat crop. This occurred in spite of continuous efforts to detect and stay ahead of such disease hazards, with an excellent national program of research in wheat breeding and pathology.

The non-sensitivity to day length of the Mexican wheats and of the Taiwan rice varieties extends the range of their mobility but also enhances the hazards of introducing these crops into new environments with unknown local disease or insect hazards. Some of the Mexican wheats are susceptible to yellow rust and to loose smut under Indian conditions. The Taiwan rices are susceptible to a bacterial leaf blight, to the blast disease, and to the "tungro" and other virus diseases that are common in the rice bowl countries and in South Asia. Developing nations that have depended heavily on a series of action-oriented programs and have deferred the building of the scientific base for their agricultural development now are facing hard choices, whether to continue to depend upon the plodding advances of traditional agriculture or to introduce materials from strange environments and hope that the disease epidemics and other hazards common to intensified agriculture in other regions of the world somehow will not strike them. The development of adequate national systems of agricultural science and technology can no longer be ignored by nations that move into intensified agriculture with the biological forces and hazards involved.

With present germ plasm resources and improved methods of research for crop improvement, under conditions where three generations can be grown annually, the adaptation of modern productive materials and practices to local environments can proceed rapidly if the institutional base with qualified personnel is available.

Extension and Community Development

Research in tropical and sub-tropical areas during the last five years has supplied basic materials and knowledge capable of increasing yields of major food grains by two to fourfold in most developing countries. With such materials available for adaptation and use, it seems reasonable to question the wisdom of continuing to rely so heavily on action or extension programs that are concerned primarily with the re-shuffling of local materials and practices.

It has been well demonstrated, in Mexico and elsewhere, that farmers in traditional agricultural societies will readily adopt new, superior materials and practices. The national average wheat yields in Mexico were increased from approximately 11 bushels in 1943 to more than 39 bushels in the past two years, with almost the entire wheat acreage of Mexico shifting over to the productive new dwarf and semi-dwarf varieties within four years time.

The productive innovations for doubling or trebling crop yields require higher investments by farmers for improved seeds, fertilizers and pest control chemicals. These inputs must be applied in the proper combinations for specific environments if risks are to be minimized and full benefits realized. The extension agents who transfer new information to farmers must give first attention to the substantive inputs - the "what" as well as "how" - to extend. Extension workers should be tied as closely as possible to the source of innovations, and training programs should be conducted at the adaptive research centers that serve the specific local environment.

Program objectives should be clarified -- between agricultural production and community development. If the goal is to achieve maximum output from the agricultural sector we cannot confuse the essential agricultural modernization practices with rural social welfare issues. The parceling of land, the resistance to the efficiencies and time-saving features of mechanization in order to maintain a high human labor force in the agricultural sector, and other similar factors, should be reassessed and modified as necessary to accelerate agricultural productivity.

Establishing Institutionalized Agricultural Science in the LDC's

The initiative to develop national systems of agricultural science and technology in the developing countries may have to come largely from those nations that now have such an institutionalized base and understand its significance. The host countries must, of course, be willing to explore the prospects for scientific development and be willing to make local institutional changes.

In our highly integrated scientific and industrialized society our individual or institutional role is that of a well meshed component of a smoothly operating system or machine. In a developing nation we may be only a spare part for a machine that does not yet exist. Our job, therefore, is to identify the stage of development or the needs of developing countries -- to start where they are and adapt our training and experience to their needs. We cannot expect them to adjust their whole social and organizational pattern to suit our experience and convenience -- even though some institutional change on their part must occur.

The reviews of needs and opportunities should be conducted by joint teams composed of agriculturists from the assisting and the recipient country with experience in organization or administrative management as well as in specific scientific disciplines. The "Joint Indo-American Teams" to review agricultural research and education in India in 1955, 1959, and 1963 included U.S. members from the U.S.D.A., a land-grant university, and from a veterinary science or animal science faculty. The Indian counterparts were from similar central and state government institutions and had varied scientific backgrounds. The broad base of experience of team members, and the joint review produced meaningful recommendations of high acceptability to the Indian leadership.

To many, the terms research or science suggests a luxury input or academic entrepreneurship that developing nations can ill afford. It is essential, therefore, that the change agent potential of "research" be made clearly evident to LDC leaders. The applied or adaptive research programs for improvement of food crop production with national leadership for broadly applicable results, as conducted in Mexico, Colombia, Chile, and India, provide convincing vehicles for selling the merits of science and technology in agricultural development.

As pointed out earlier, many of the LDC's have emerging centers of strength at the central government level or in the states and regions that might be structured into nationally institutionalized systems by furnishing deficient components. A.I.D. and the land-grant universities - and I would add the U.S.D.A. - have an excellent opportunity to assist in building the necessary added strength into countries in which we are already cooperating.

A.I.D. - U.S. University Relations in Agricultural Development Abroad

The cooperation between A.I.D. and the U.S. universities for improvement of agriculture in the less developed countries should not differ substantially from the type of relations that have prevailed in the cooperative efforts of the U.S.D.A. and the agricultural experiment stations in serving domestic agriculture.

There are, of course, added dimensions in terms of the needs and wishes of the foreign or host government. There are logistic problems in serving the personal and professional needs of personnel overseas. In some countries there are complicating factors in the use of local currencies accumulated under sales of U.S. commodities under PL 480. In many cooperative projects, other organizations also are involved, including private foundations, UN Agencies, and other governments. The patterns of responsibility in foreign governments are frequently different from our own with agricultural research a function of the Ministry of Agriculture, agricultural education frequently under the Ministry of Education, and extension or rural development activities handled in a variety of ways.

In our associations with foreign governments, we are aware of certain legal limitations and national security requirements, as well as less clearly defined questions of national interest that are important in maintaining mutual confidence in our international affairs. When a professor leaves his academic world, where he is primarily concerned with the generation and communication of new knowledge, to enter the technical assistance world, which is concerned largely with the use and application

of knowledge, he enters the arena of international relations where some rules of the game may be different from those of the academic world.

Foreign assignments present conflicting value premises for the academic person, from the standpoint of career expectancies. A professor working in an identified discipline which has institutional support in a department at the university performs research to maximize his promotion and tenure possibliities. This kind of visibility is not always attainable in a technical assistance framework. Most academic specialties cannot be, or should not be, used in their purest form in technical assistance programs where there is a need to synthesize and generalize, and for an interdisciplinary approach to problems of the less developed countries. Fire-fighting is a major characteristic of many of these problems, which tend to become the property of the closest man with a pail of water, with few questions asked as to the qualifications of the fireman.

A professor away from established routines and standards of performance, and plunged into the pressing problems of technical assistance overseas, soon loses an identification on the home campus. If he is away for some considerable period of time, he may lose research and teaching opportunities, which tends to lower his visibility in his established disciplinary area. Thus, it is imperative that the universities and the agencies interested in technical assistance make some considerable effort to equate the career expectancies of the technical assistance professional and the academician. This is one of the great challenges of A.I.D.-

university relationships in the immediate future.

It is recognized that U.S. institutions participating in the foreign aid program can no longer be expected to draw upon resources that are urgently required for expanding domestic activities. Special provisions are being incorporated in the Foreign Assistance Act for 1967 to permit the use of foreign aid funds to build additional domestic institutional capability for supporting foreign aid programs. The pattern of administration and use of such funds under the requested new authority remains to be developed. We would anticipate, however, that priority attention would be given to those institutions that are actively participating in our foreign aid efforts and that have demonstrated over a period of years their serious concern with this added dimension in their total institutional responsibilities.

The building of personnel with greater understanding of development processes, to furnish sustained leadership to technical assistance efforts abroad, is a high priority need, as is the strengthening of the total manpower pool for agricultural assistance programs.

There will be many specific understandings to be developed in expanding the A.I.D. - university relations but past experience has furnished guidelines that should simplify future cooperative arrangements. Our principal attention should be addressed to 1) a mutual understanding of objectives, 2) a clear assignment of responsibility, and 3) a clear definition of authority. When these points are agreed upon, differences and administrative problems can be minimized and we can focus attention on the same goal lines.

The strong emphasis of this paper on institutionalized national science and technology may tend to reflect a personal career bias from participation in this approach to U.S. and international agricultural development during the past 30 years. However, the following excerpt from an editorial in the Des Moines Register of April 21, 1966, entitled "Improving our Foreign AID" endorses and rather adequately summarizes the concepts offered for our consideration today:

> "The resources of the United States Department of Agriculture and of the Land Grant agricultural colleges still are not being mobilized sufficiently for the job that must be done. One of the greatest needs is for adaptive research, in cooperation with local governments, to develop crop varieties and improve livestock.
>
> "Research teams from the U.S. should be given the assignment of developing varieties and production practices which will raise yields by 50 percent or more. This can be done, and we have waited too long to make a major effort in farm research adapted to local conditions."

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SCIENCE AND TECHNOLOGY IN INTERNATIONAL AGRICULTURE

I welcome this return to Beltsville where I enjoyed the many stimulating professional contacts during my association with the national research programs in crops, soils and agricultural engineering from 1944 to 1951. It was a privilege to be a part of the U.S. Department of Agriculture research program for the twenty years beginning in 1936--the period when the solid base was established in agricultural science and technolcgy for developing the efficiencies and abundance in our agricultural industry.

I cannot claim to be a pioneer at the Plant Industry Station but some of the facilities were still in process of development and improvement when I first reported for duty in 1944. I recall a letter from the Plant Industry Station employees complaining about the poor bus service from Washington, the walk in the mud from highway U.S. 1 to the Plant Industry Station buildings, and the fact that there were no eating facilities at the station. This letter was addressed to Mrs. Eleanor Roosevelt, requesting her to give these matters her attention and support. The necessary action was taken.

Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the Meeting of the Organization of Professional Employees, Department of Agriculture, Plant Industry Station, Beltsville, Maryland.

January 11, 1966

I have recalled, on numerous occasions, one meeting that was held in this auditorium, early in 1952, when Secretary Charles Brannan talked about the U.S. agricultural surpluses that had accumulated because of the stepped-up production to meet the needs of the Korean war. The Secretary pointed out that these surpluses would disappear if each American would consume only a few more eggs or few more squares of butter each year. As we left that meeting, Dr. Luis Bramao, a soil scientist from Portugal who was in the U.S. as a Rockefeller Foundation fellow studying at Cornell University and who was spending a few months at the Beltsville soils laboratories, commented "You people have a problem, but it is a beautiful problem".

Today, with the world food supply and population growth coming increasingly into sharper focus, we are confronted with a new look at U.S. agriculture in relation to international requirements. U.S. surpluses are diminishing and we are beginning to think more in terms of "available supplies" and less in terms of "surpluses". The concern for international agriculture is becoming real - it looms as one of the most serious problems ahead, perhaps for the balance of this century.

The U.S. Stake in International Agriculture

Many who in the past few decades have tended to discourage our foreign aid efforts from attention to improvement of production of agricultural commodities abroad that are in over-abundant supply in the U.S. have failed to take into account the dependence of our agricultural development on materials and knowledge from other nations. It has been estimated that approximately half of the total crop production in the United States, measured in dollar value, comes from plants or crops first used by

the Indians, and were available to our first settlers, but the remaining half and many of our major food grains were not among these indigenous resources. Wheat, our major food grain, was among those missing. We have depended heavily on the world-wide resources of plant germ plasm, and we are still doing so, with an estimated 300,000 plants that have been introduced over the years as basic working materials to tool up our crop production efficiency.

We have derived many benefits from the agricultural research conducted abroad. The studies on virus diseases of citrus in Brazil in the mid-1940s was most useful in solving the losses from the complex of viruses in our citrus growing regions. The research overseas on sugar beet diseases helped us to realize that the "Salinas Yellows" condition of beets in the Salinas Valley of California was not a physiological condition but was caused by a virus that was reducing yields by up to 40 percent. The research in Cuba and subsequently in Colombia on the "Hoja blanca" or white leaf disease of rice has been most helpful in guarding against losses from this disease in the U.S. The studies in Mexico on the Mexican fruit fly and other insects has helped to protect our citrus industries in Texas and California from these pests. Also, entomologists have found biological control agents for a number of serious insect pests from their studies in other countries. The International Cereal Disease Nurseries have helped to identify new virulent races of rusts and other diseases abroad before they became a problem here. The research on African Swine fever in Kenya not only is furnishing background information for benefit of the U.S. livestock industry but also has been most effective in establishing a standard of excellence for research in Kenya.

We could perhaps spend all of the time during this hour enumerating the assistance we have had from the agricultural materials and the scientific work abroad. International cooperation in agriculture dates back to the first settlements in America. We have benefitted continuously and if the traffic on this two-way street now becomes a bit heavier on the out-bound lane perhaps it is right and just that it be that way.

The Agricultural Program of the Rockefeller Foundation

I received the invitation to speak at this meeting through a letter from Mr. Walter Carleton on July 27, 1965, while I was still serving as Director of the Agricultural Sciences Program of the Rockefeller Foundation. Mr. Carleton expressed the desire of the program committee to have the subject of International Agriculture reviewed from the standpoint of the Federal Government and Private Foundations.

I would assume that only a few of you are aware of the role played by the late former Secretary of Agriculture Henry A. Wallace in the establishment of the agricultural program of the Rockefeller Foundation. In 1941, when Mr. Wallace was Vice President of the United States, he attended some ceremonies in Mexico as the representative of the U.S. Government and while in Mexico, met with their Minister of Agriculture to discuss efforts to improve the agricultural economy of that country. On his return, in February 1941, Mr. Wallace met with Mr. Raymond Fosdick, then President of the Rockefeller Foundation, and urged Mr. Fosdick to consider the initiation of an agricultural program similar to the Rockefeller Foundation work in medical research and demonstrations to improve the production of Mexico's basic food crops. Mr. Wallace pointed out that even an increase of 10 percent in production of corn and beans would be a tremendous boon to the Mexican agricultural economy.

The Rockefeller Foundation initiated a research program in Mexico in 1943, with first attention to the improvement of production of corn and wheat. Later, projects were added to improve production of potatoes, beans, and forage crops, and to give attention to poultry production, animal nutrition and animal health.

While the Mexican Agricultural Program was the first venture in agricultural sciences work abroad for the Rockefeller Foundation, other Rockefeller Boards had supported earlier rural development work in the United States. The General Education Board, in 1906 and in later years, supplied nearly $1 million for the work of Seaman A. Knapp who pioneered the farm demonstrations that led to the Smith-Lever Act of 1914 establishing the Agricultural Extension work in the United States.

The pattern of operation of the Rockefeller Foundation's agricultural sciences programs is basically similar to that of the U.S.D.A., especially in the crop improvement research. The research is nationally programmed, cooperative with the Federal Ministry of Agriculture, and operates from a main or central station throughout the regions in which the specific crop is important. The field staff, although small in number, is highly trained with emphasis on young scientists educated through the Ph.D. level in their respective scientific field. The research is inter-disciplinary, with emphasis on plant breeding, pathology, soils, entomology, etc. The basic objective is to conduct problem-oriented research that will improve materials and practices that will be as fool-proof and risk-free for farmers as possible. It is recognized that research must have a high degree of continuity and so a task is approached with the understanding that it will be continued until it is completed, or an effective contribution is made, rather than establishing superficial two-year, four-year, or six-year limits.

The training of young nationals is an integral, important part of the program with some attention to in-service training for technicians but with principal emphasis on training as scientists through the M.S. and eventually the Ph.D. level, to insure depth of understanding and strong leadership that can carry on as the Rockefeller Foundation staff withdraws.

As the research programs progress, with identifiable results and with a growing complement of young scientists, they are structured into national organizations for research, education, and extension with national and regional centers to carry on continuing activities.

The Rockefeller Foundation program in the agricultural sciences extended from the initial work established in Mexico in 1943, to similar projects in Colombia in 1950, in Chile in 1955, and India in 1956. In 1959 a further expansion into Asia was made through the establishment of the International Rice Research Institute in the Philippines, in collaboration with the Ford Foundation and the Government of the Philippines.

Progress and Results

The total cost of the operating program of the Foundation, cooperative with the three countries in Latin America and in India, together with the expansion into international dimensions from the headquarters for corn and wheat improvement in Mexico that extended into Central and South America, and from the corn improvement program in India that extended into Thailand and the Philippines, from the

initiation of the program in 1943 and through 1965, has totalled less than $29 million. This does not include the investment of approximately $3.6 million for the International Rice Research Institute in operating costs, for which the Ford Foundation supplied about $7.5 million for capital costs for land, buildings, and equipment. The Ford Foundation also has furnished $1,550,000 for training and conferences, together with $635,000 for operating costs. The largest field staff at any given location was the 18 full time staff members in Mexico for a few years, and the total field staff of trained scientists in recent years has ranged between 45 and 50.

There are a number of tangible results that furnish a measure of the contributions from the 22 years of cooperation. In wheat improvement, for which substantial initial guidance and background breeding material was furnished through the late Dr. B. B. Bayles, who was in charge of U.S.D.A. wheat investigations program, the program has produced a large number of high yielding varieties, adapted to various growing conditions in Mexico, Colombia, Chile, and elsewhere in Latin America. As a result of this program, wheats are now available suited for growing in the Western Hemisphere from Canada through Chile. Some of these varieties have been utilized in Africa, and also in the Near East countries where during the past five years 30 young plant breeders have been trained through participation in the cooperative program in Mexico. The Mexican semi-dwarf and dwarf wheats which were bred through the use of the Norin 10 and Norin 33 selections that were introduced from Japan in about 1947 by Dr. S. C. Salmon of the U.S.D.A., while he was serving on General MacArthur's staff, have proved to be widely adapted. They are non-photosensitive so can be grown at almost any latitude, extending from the equator to 45 or 50 degrees north or south. Some of these wheats have been tested in India and

Pakistan during the past two years.

In the summer of 1965, approximately 350 tons of these new commerical wheat varieties from Mexico were shipped to India and approximately 450 tons to Pakistan for planting in extensive field demonstrations. Although these varieties are generally adapted to growing conditions in India and Pakistan, we know that they are lacking in rust resistance under certain conditions and also should be improved for grain quality to meet local needs. They do represent valuable basic breeding stock for further adaptive research and it should be possible within two or three years time to select suitable varieties for many of India's and Pakistan's major wheat producing regions. These wheats were instrumental in increasing Mexico's yields from approximately 11 bushels per acre in 1943 to over 39 bushels per acre in 1964-1965. They have the potential for supplying equal yield increases in India where the food grain deficit is critical this year and it is likely to continue to be so in the foreseeable future.

The corn improvement program in Latin America has likewise produced hybrids and selections suitable for growing in the principal corn growing regions of Mexico, Central America, Colombia, and elsewhere in South America. A germ plasm bank of about 12,000 lines is maintained in the principal breeding centers in Mexico, Colombia and Brazil. The Indian program, which was initiated in 1957 and has produced adapted hybrids for most of the major corn growing regions in India, including the Gangetic Plain, the Himalayn Hills of North India and the South Indian Plateau, has been expanded to cooperative research in Thailand and the Philippines. Corn improvement research was initiated by the Foundation

in Africa in 1963, in cooperation with the University of Ibadan. This work is closely associated with the corn-sorghum improvement project that has been initiated by the U.S.D.A. under support from A.I.D., with a regional headquarters in East Africa and a second headquarters in West Africa.

The sorghums and millets are important food crops in India where each meakes up approximately 20 percent of the basic or staple food for India. Research on these crops, initiated in 1957 has produced varieties and hybrids that have the capacity to double the yields of the local varieties in many regions of India. Substantial additional adaptive research will be necessary to breed and select varieties that are suited for growing under the different environmental conditions and to meet the hazards of specific insects and diseases.

For attention to problems of rice improvement and production, the Rockefeller Foundation efforts have taken a somewhat different form. Extensive surveys of the needs and potentials in the rice bowl in 1954 and 1955 disclosed that one of the principal handicaps was the lack of strong research centers that would give attention to multiple aspects of rice improvement. In 1959, the Ford Foundation and Rockefeller Foundation, in collaboration with the Government of the Philippines, agreed to establish a rice research center at Los Banos, adjacent to the College of Agriculture of the University of the Philippines, about 40 miles south of Manila. The Institute now has a staff of 28 scientists selected from the U. S. and a number of countries in the rice bowl, and research attention is given to nearly every aspect of rice production and improvement.

Mr. Henry Beachell, who for many years directed the rice improvement research at the Rice-Pasture Experiment Station at Beaumont, Texas, has joined the staff of the Institute and is furnishing the principal guidance to the breeding program. A number of varieties from Taiwan, as well as some of the Beaumont selections, have demonstrated outstanding yielding capacity in the Philippines, India, and elsewhere under tropical or semi-tropical conditions. Some of these varieties also are non photosensitive so have a wide range of adaptation. The short, strong-strawed rices, similar to the semi-dwarf and dwarf wheat varieties have a capacity to increase in yield with applications of N ranging up to 120 pounds or more of nitrogen per acre, in contrast with the upper limit of approximately 40 pounds of nitrogen for the rice and wheat varieties commonly grown in India and other developing countries under poor soil conditions.

Institutional Development

The principal long-term objective of the Foundation's cooperating programs is to establish indigenous research, education, and extension centers so that continuing attention can be given to agricultural research and development as the Foundation staff withdraws. Steps were taken several years ago to strengthen the agricultural research and education center at Chapingo and to locate the headquarters for the national extension program at that center which is being strengthened with combined support from the Rockefeller Foundation, Ford Foundation, Inter-American Development Bank, and A.I.D. Regional stations at Toluca, Sonora, Vera Cruz, as well as elsewhere in Mexico, also will be improved, to establish a national program and facilities for continued agricultural development.

In Colombia, similarly, the research and training program of the Foundation has furnished the nucleus for establishment of a nation-wide agricultural research, education, and extension system with central facilities at Tibaitata, near Bogota, and regional stations associated with the faculties of agronomy at Palmyra and Medellin, and elsewhere in agricultural regions. In addition to the Rockefeller Foundation, the Ford Foundation and Kellogg Foundation are participating in this coordinated development. Plans are under way for the University of Nebraska to participate under A.I.D. support, and the Inter-American Development Bank and the World Bank have both indicated interest in financial support for the development of facilities.

The Foundation cooperation in Chile included attention to the establishment and improvement of research stations. Excellent facilities have been constructed for the central headquarters at Santiago, and at Temuco and Chillan to serve the

central valley regions to the south of Santiago. A special review team to study the organization of research for the Ministry of Agriculture was supplied by the Rockefeller Foundation in 1962. This team was chaired by Dr. M. W. Parker and included Dr. W. H. Allaway both of the U.S.D.A. The recommendations of this team were accepted almost in their entirety and are in the process of being implemented by the Ministry.

Institutional development in India includes the establishment of a graduate school at the Indian Agricultural Research Institute. This was inaugurated in 1958 and in recent years has had 400 students enrolled, of which one-half are pursuing the Master of Science degree and the balance the Ph.D. degree. Many of these students have participated in the crop improvement research programs and have an appreciation for the need to direct research efforts toward the practical problems confronting India's agriculture.

The coordinated maize improvement scheme has furnished a new pattern for coordination of central and state government institutions, similar to the U.S.D.A. and state agricultural experiment station relationships, and has been most effective in clarifying GOI and state government responsibilities for agriculture. The Foundation leadership in India, particularly Dr. Ralph W. Cummings who was formerly Director of the North Carolina State Agricultural Experiment Station, has furnished effective guidance for the revision of research and education institutions in India.

The several joint Indo-American Teams which included U.S.D.A. participation have furnished basic guides for the re-orientation of India's research and education. I had the privilege of serving on the first such joint

Indo-American Team in 1955, Dr. Martin G. Weiss served on the second team in 1959, and Dr. M. W. Parker was chairman of the most recent team which in 1963-64 developed recommendations that are now being put into effect by the Ministry of Agriculture. The latter team was financed by the Rockefeller Foundation but the earlier teams were supported by the predecessor agencies of the A.I.D.

The Rockefeller Foundation contributed to the development of the experiment stations of the Agricultural Universities of the Punjab and the Uttar Pradesh, with grants of funds for the purchase of laboratory and field equipment. The principal support for the agricultural university development program in India is being supplied, however, by A.I.D. through contracts with the Universities of Illinois, Ohio State, Missouri, Kansas State and Tennessee.

The International Rice Research Institute in the Philippines is achieving growing recognition as the world's major rice research center. It also has a strong influence in education and training, with approximately 60 scientists from different countries in residence each year, participating in the research program of the Institute, coupled with graduate training at the adjacent college of agriculture of the University of the Philippines. Rockefeller Foundation personnel collaborated actively in the recent action that has been taken to upgrade the facilities and program of the College of Agriculture which culminated in an arrangement whereby Cornell University is furnishing principal staff competence under financial support from the Ford Foundation. This collaborative effort, with substantial initiative from the Rockefeller Foundation, also resulted in a loan of $6 million by the World Bank, the first such loan the Bank has made to an agricultural educational institution.

Related Activities

Principal attention has been given in the foregoing discussion to the research program for improvement of food crops. The Rockefeller Foundation also has given support to extension activities in Mexico and Colombia, in the form of a research information specialist in each country. At the International Rice Research Institute, two staff members have been employed for work in extension methods and extension training. During the past year, a special program was established for in-service training at the Institute for the regional rice production specialists for the Philippines.

In India, the Foundation furnished substantial initiative for the drafting of the legislation and plans for the National Seeds Corporation, and special provisions were included in the legislation for participation by private seed companies.

The cooperation also has included research on poultry improvement in Mexico and Colombia, on animal nutrition and animal health in each of these countries, and on animal nutrition in Chile. Soil management and cultural practices research has received attention in all of the programs and agricultural engineers have been involved in experiment station development and operations, as well as in guiding the seed production and processing work in India. Research on mechanization under tropical conditions has been initiated within the past year at the IRRI, under a project financed by the A.I.D.

Some Principles or Guidelines for Agricultural Development

Although we appreciate the importance of the specific results from the cooperative research programs, measured in terms of numbers of new varieties,

increased yields, etc., the principal benefit is the knowledge and experience that may guide similar and more extensive activities throughout the world. The following points are worthy of consideration:

1. The importance of establishing a solid base of science and technology within the cooperating country. This has been demonstrated through the research of the U.S.D.A. and cooperating agricultural experiment stations in the U.S. over the past century. The cooperating program of the Rockefeller Foundation also was grounded on this basic principal, stressing the importance of the search for materials and information that fit the specific needs of the cooperating country.

2. Continuity. The development of a new crop variety, or reliable progress in other agricultural improvement activities usually requires 10 years for the innovation to be developed and put into practice. This can be shortened somewhat under tropical conditions where growing seasons are essentially continuous. It is essential that cooperating U.S. scientists have an opportunity to become acquainted with the unfamiliar, and frequently widely different, conditions prevailing in tropical or sub-tropical regions and also that they remain associated with a given research and development project over a sufficient period to gain the confidence of their cooperating local scientific and administrative colleagues. We are dealing with biological entities, with ever changing complexes of diseases and pests, so continuity of attention to such hazards is essential. While it is important that U.S. personnel work themselves out of a job in foreign technical cooperation, it is still more important that they effectively work their local colleagues into the job, in the

type of research or educational institution and a national system of agricultural research and development that will have stability and sustained contributions to agricultural development.

3. National coordinated programs for research and development. Dr. H. K. Hayes, Professor Emeritus of Plant Breeding and Genetics at the University of Minnesota, has stated that the practical development of hybrid corn in the U.S. stemmed from the national coordinated program led by Dr. F. D. Richey beginning in 1923. The excellent research contributions of the preceding two or more decades made by Drs. Hayes, East, Collins, Jones, and others really did not add up to anything directly useful on American farms. It was the cooperative working in the decade beginning in 1923 that really put together the new knowledge in an effective package that culminated in the use of corn hybrids in the corn belt beginning in the early 1930s.

4. Strong regional or state and community adaptive research and demonstration programs. The experience with corn improvement in the U.S., in which it was found necessary to establish a regional research program in the Southeastern U.S., where the hybrids developed in the corn belt were not well adapted, stresses the importance of effective coordinated research for improvement of crop production in the different climatic regions of a country. We are well aware of this also as we look over the pattern of wheat improvement research in the U.S., with regional attention given to research on the different classes of wheat. We fully recognize that we cannot transfer the wheats from Mexico or rice varieties from Taiwan to India, or even within India, to confront all of the different environments and combinations of disease and insect hazards, without strong adaptive research. Our experience in the development and use of

strong inter-disciplinary research centers may well minimize the number of regional or local adaptive research locations. It is essential that we realize that "improved seed" is a dynamic input and that improved varieties have a life span of only three to five years so must be constantly re-worked to stay ahead of changing limiting hazards.

5. Scientific leadership competent to identify the problems confronting agricultural development in a country and to plan the effective search for remedies or improvements. The experience of the U.S.D.A. and of the Rockefeller Foundation in utilizing a relatively small corps of well trained scientists to focus on well-defined problems has demonstrated the efficiency of this type of research effort in transforming traditional agriculture.

6. The development of indigenous institutions is dependent upon competent scientific leadership. Training programs designed to permit withdrawal of cooperating U.S. technical personnel, and to build indigenous capability for agricultural research and development must give attention to the education of the foreign personnel through both academic and in-service experience so they will have adequate depth of understanding for effective leadership. The study tours of short duration that merely permit foreign students of scientists to observe certain practices in the U.S. are relatively ineffective except for well trained individuals who already have a solid base of understanding of the science and technology with which they will be involved. It is essential, of course, that the education and training be developed around the needs of the home country.

Time does not permit the review of the agricultural research currently under way in A.I.D. and the projects in which the U.S.D.A. is participating to an

increasing extent. I should like to call attention to the nature of such cooperative work, however, which is handled under the following projects:

Title	Agency	Term	Funds
1. Development and use of improved varieties of the major cereal crops of Africa.	ARS	4/16/63 - 6/30/68	$586,625
2. Research on the sterility method of tsetse fly control (Africa)	ARS	6/14/63 - 6/30/68	$329,840
3. Analysis of factors associated with differences and changes in agricultural production in the less developed countries.	ERS	3/20/63 - 6/30/67	$847,185

In view of the growing seriousness of the world food and population situation, we can fully expect more collaboration and interdependence of the research and development programs of the U.S.D.A. and the A.I.D. The experience of the U.S.D.A. and the Rockefeller Foundation in agricultural science has been very similar and can furnish substantial guidance for our future collaborative efforts to improve food production in the many countries where levels of nutrition are inadequate and in some cases are still declining.

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The World Food Problem and What the U. S. Can Do About It

The subject I have been invited to discuss this morning brings to mind the meeting at the Beltsville Research Center about 14 years ago when Secretary of Agriculture Charles F. Brannan reviewed special steps that were being taken to dispose of mounting U. S. farm surpluses. As we left the Plant Industry Station Auditorium, a young Portuguese soil scientist who was in training at Beltsville, commented, "You folks have a problem, but it is a beautiful problem".

The concern of U. S. leadership about our domestic agriculture has shifted since 1952, and rather abruptly within the last two years. President Johnson, in his message to Congress on the foreign aid program on February 1, 1966 stated, "The problem of hunger is a continuing crisis. In many parts of the world we witness both the ravages of famine borne of natural disaster and the failure of food production to keep pace with rising needs."

"This is a catastrophe for all of us. It must be dealt with by all who can help. In many other countries food output is also falling behind population growth. We cannot meet the world food needs of the future, however willing we are to share our abundance. Nor would it serve the common interest if we could.

"The solution is clear: an all-out effort to enable the developing countries to supply their own food needs, through their own production

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the National Agricultural Policy Conference, Lake Hope, Ohio, September 13, 1966

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or through improved capacity to buy in the world market."

In his address to the American Legion Convention in Washington, D.C. on August 31, the President stated, "The poor nations are on a road mined with potential turmoil. Poverty - and the hatred of poverty - can detonate those mines. The raging search and quest for bread may bring on the reality of chaos." The President emphasized that while aid for the poor nations is in our self interest, "Our assistance to these nations, our involvement in their affairs, will be no greater than they choose to have it."

Mr. William S. Gaud, who became the Administrator of the Agency for International Development on August 1, considers the solution of the problem of food and hunger our most important job. The staff of the Agency has been directed to give special emphasis to this aspect of our foreign aid effort.

The first thing the U. S. can do about the world food problem is to recognize its seriousness. There is such awareness in our top government leadership. There is much yet to be done, however, in achieving an appreciation of the significance of world hunger on the part of the general public.

World Food Needs and Production Prospects

The developing countries are importing approximately 30 million tons of food grains in 1966. It is estimated that by 1985 they will require an additional 88 million tons. If the United States would restore to production the more than 50 million acres now in reserve, there would still

be, in 1985, a world shortage of approximately 12 million tons.

It is increasingly clear from the draw down of stocks in the major grain exporting countries this year that a gradual increase in production in these countries must be accomplished concurrently with the development of higher levels of self-sufficiency in the food deficit nations.

The U.S.D.A. announced on August 8 an increase of 8.9 million acres for wheat production. This is beyond the 7.7 million acre increase announced last May, furnishing a total allowable acreage for harvest in 1967 of 68.2 million acres. It is hoped that the harvest in 1967 will move up to 1.6 billion bushels, as compared with an estimated 1.2 billion in 1966.

The world demands for wheat are growing at the rate of 300 million bushels annually so it is apparent that restoration of a sizeable portion of our reserve agricultural lands to production this year will have only a limited impact on long term needs.

There is, of course, no real assurance that the new U. S. production goals will be achieved since the final decision to plant rests with the farmers who may yet require assurance that long term trends in world food requirements will justify their added investments in machines and other production inputs.

The Department of Agriculture and the Agency for International Development will coordinate activities closely in planning and implementing future food aid programs. It will, of course, be necessary to develop the

most accurate estimates possible of food needs in the developing countries in order to guide crop acreage allotments in the United States.

Building Self-Help Capability

In presenting his message to Congress on "A War on Hunger", the President stated that, "To strengthen these programs our food aid and economic assistance must be closely linked. Together they must relate to efforts in developing countries to improve their own agriculture."

This affirms the views of the President expressed in his Foreign Aid message, that, "The United States can never do more than supplement the efforts of the developing countries themselves. They must supply most of the capital, the know-how, and the will to progress. If they do, we can and will help. If they do not, nothing we can supply will substitute."

U. S. foreign aid efforts, from the initiation of the Point IV program, have given only limited assistance to the developing countries in improving production of commodities in surplus in the United States, including the major food grains, wheat, and rice. During the past 11 years, under the Food for Peace program that was established under Public Law 480, food aid was regarded as a constructive outlet for surplus farm products.

Future Public Law 480 food imports from the U. S. will be analyzed carefully to determine their impact on efforts of food deficit countries to enhance their own food production, or to improve their agricultural economy so as to reduce dependence on concessional food. It has been suggested that in some countries the Public Law 480 food grains were regarded as "a source

of cheap food for poor people" and government leaders failed to take the vigorous measures required to increase domestic agricultural production. The food deficit nations now will be expected to make some hard decisions and chart their courses for greater agricultural self-sufficiency.

We should, of course, assess the magnitude of the challenge to the developing countries "to achieve a greater level of self-help in food production". In our 15 years of cooperation and assistance, advances in agricultural productivity in the developing nations have been inadequate. A part of this shortfall stems from neglect of attention to improvement of production of the basic food grains. A significant question, however, is whether we have given sufficiently broad attention to the major "production" components of the agricultural sector.

As a base for guiding future cooperative efforts an important initial step would be the careful analysis of the agricultural sector of the developing nations to assess the adequacy of attention to the principal components or elements. As a minimum, we might consider the following:

1. General Government Policies. Government administrative and political leaders must allocate sufficient national budgets, including foreign exchange resources as well as local funds, for investment in agriculture to encourage production and achieve a growth rate that will move beyond national subsistance levels.

There is substantial evidence that farmers throughout the world are economic men; they will respond if furnished fair and equitable prices for what they produce, together with reasonable prices for the inputs they

must purchase. Other incentives such as equitable credit and land tenure arrangements also should be reviewed.

2. New Technology, Including Research, Extension, and Education. The sustained development and application of new knowledge through science and technology has been the major force in the growth of American agriculture. This aspect of agricultural development has been most seriously neglected in the food deficit nations.

Our cooperative foreign aid activities also have failed to emphasize the building of indigenous bases of science and technology. As Dr. T. W. Schultz of the University of Chicago stated in his presentation to the House Committee on Agriculture on February 18, 1966, "Although we have developed an outstandingly productive agriculture in the United States, we have not done well as builders of agriculture abroad. We have long been hampered by the 'extension bias' and as a consequence agricultural research has been postponed, put off, and grossly neglected. When research has been undertaken, altogether too little attention has been given to the development of viable agricultural research centers."

This component of the agricultural development process must be strengthened if food deficit nations are to build any significant capability for self-sufficiency.

3. Availability of Production Inputs. Increased production per acre will not be achieved on a sustained basis unless farmers have access to the inputs of improved crop varieties, fertilizers, pesticides, and improved tools or machines. These inputs must not only be available but also fairly

priced if farmers are to make the investment to achieve increased production and to structure a truly commercial agriculture.

4. Markets and Related Services. Increased attention must be given to assured markets, including domestic and foreign outlets, as well as to transportation, storage, and processing organizations and facilities.

5. Institutions. The upgrading of agriculture requires the restructuring of institutions, including the development of national programs for research; institutions for education and extension; for rural credit; and for other services. Self-help mechanisms of rural people such as cooperatives or farmer associations should be stimulated in order to achieve maximum involvement of the masses of people on the land who must be activated or energized to achieve agricultural and rural development.

In order to apply U. S. resources more efficiently to the needs of developing countries, the agricultural sectors should be studied to determine which components may require special attention from indigenous leadership, or outside assistance, or both. Joint review teams should be selected carefully to insure inclusion of individuals with meaningful experience in the respective "component" or program areas to be reviewed.

The Change Agents in Agricultural Development

We have been rather unsophisticated in identifying effective approaches to improving traditional agriculture. We continue to find heavy emphasis on single inputs as the essential ingredient for instant agricultural development, even though experience in U. S. agriculture demonstrated nearly a generation ago the importance of integrated attention to soil fertility and

hybrids developed for the corn belt section of the Mid-Western U. S. were not well suited, or productive, in the Southeastern States.

Experience in India in 1955-56 made it clear that we could not transfer U. S. dent corns, developed for livestock feed, to a country that preferred flint-type grains of corn for direct human consumption. Subsequently, in India, we learned to appreciate the hazards of new and strange diseases and insects of crops, including the very destructive stalk borer Chilo zonellus that attacks corn and sorghums, the Atherigonia species of shoot fly that attacks sorghums, as well as other handicaps to food grain production in tropical and subtropical environments.

Adaptive Research

The Mondale Amendment to the Foreign Assistance Act of 1966 provides that, "In developing countries where food production is not meeting the demands of populations, or diets are seriously deficient, high priority shall be given to increasing agricultural production, particularly through adaptive agricultural research programsbased on cooperative undertakings between universities and research institutions in the United States and in the developing countries."

The benefits of such research, to fit innovations to the needs of the society that is expected to accept them, are well demonstrated. Wheat breeding and selection, utilizing the germ plasm of the "Norin" varieties introduced into the U. S. from Japan shortly after World War II, together with integrated experimentation with soil fertility and water management, made it possible to produce yields of 209 bushels of wheat per acre last year in the State of Washington, and yields of 100 bushels or more in

Mexico, Pakistan, and India. Further adaptive research is now under way with the high-yielding, red-grained Mexican wheats in India to breed and select for the amber grain color preferred by Indian consumers. Breeding and selection is under way also to incorporate resistance to the forms of rusts and smuts that are found in India.

Similar modifications are being made in the high yielding rice varieties from Taiwan that produce three to four times the yields of indigenous varieties in India. They also must be improved through added resistance to the several virus diseases, the bacterial leaf spot, and the blast disease that attacks these varieties in India.

Adaptive research is the orchestration of the variables in dynamic natural systems that is essential to insure harmony of biological innovations with their environment. This type of technical cooperation requires individuals trained in the agricultural sciences, who can identify the hazards or defects in production and who can apply promptly the effective corrective measures.

Institutional Bridges for Science and Technology

Others on the program will give special attention to the strengthening of agricultural institutions abroad. It is, of course, desirable to determine how we can provide the most effective linkage of experience from the productive and efficient U. S. agriculture to aid food deficit nations. The question is how to supply the farmer in Madras with the same capability of professional backstopping as is received by the farmer in Minnesota.

Considerable progress has been made in the transfer, through multi-disciplinary adaptive research, of improved materials and production practices. We have already mentioned the experience with the Norin wheat varieties from Japan that were adapted for use in the U. S., then in Mexico, and subsequently in India, Pakistan, the Near East countries, and Africa. The foreign migration of these improved wheats was accomplished largely through the initiative of the Rockefeller Foundation and the cooperating governments. Similarly, improved corn hybrids and production practices were adapted by the Rockefeller Foundation in Mexico, Central and South America, India, and other countries in Asia. The Rockefeller Foundation and the A.I.D. are furnishing cooperative guidance also for corn improvement research in Africa. These transfers of innovations through adaptive research have been relatively successful because of the substantial resource of U. S. experience and materials to draw upon.

In certain fields of agricultural development, U. S. experience and capability is limited and special institutions or facilities may be required to build the technological base or assemble innovative components. The International Rice Research Institute, established in the Philippines by the Rockefeller Foundation, the Ford Foundation, and the Government of the Philippines in 1962, is such a center that provides a unique base for research and development, as well as for training. Similar research and training centers for improvement of production of other crops, and also livestock, might well serve as the most effective bridge to transfer new materials and practices to the developing countries.

An immediate task is to determine how such regional or international centers can be utilized most effectively in (1) furnishing leadership for adaptive research to fit new materials and practices into specific environments in developing countries, and (2) the development of the human resources and indigenous institutions for the national systems of research, education, and extension that must be the ultimate objective.

The Agency for International Development is working out arrangements for the International Rice Research Institute to participate more actively and fully in the All India Rice Improvement Scheme that is under the leadership of the Indian Council of Agricultural Research.

We must give more attention to administrative mechanisms that will facilitate such cooperation within a "multi-lateral structure", to achieve maximum benefit in developing nations from the combined resources of the U. S. Government, other national and international organizations, private foundations, universities, and private industry.

The transfer and adaptation of innovations from abroad is an essential immediate measure for increasing agricultural production in developing countries. This, however, is the short run remedy. Sustained growth in food production and other agricultural output can be achieved only when a country has an assured, continuous flow of innovations, not only to add new productive materials and techniques but also to assure a ready response to the hazards that increase under intensified agriculture.

Our experience in the United States demonstrates fully the importance of an indigenous research and development capability for agriculture. Although approximately one-half of our agricultural production traces from foreign introductions, the real change in productivity and efficiency was brought about through the orderly application of our own science and technology from the U.S.D.A., the land-grant colleges, and the private industries related to agriculture.

Improving U. S. Capability for Foreign Agricultural Development

The development art itself is badly underdeveloped. It continues to mean all things to all people. There is a critical shortage of people who understand the development challenge or who are willing to make substantial career commitments in this area.

Most professions are oriented to the tightly structured needs of highly developed societies and cannot be transplanted easily to foreign cultures. Furthermore, less developed nations often produce demands which cannot be met through any established body of Western expertise. New skills must be developed to meet these requirements.

In recognition of these special needs, Senator George McGovern of South Dakota proposed last year, through the bill S 1212, that additional capability be built into U. S. institutions, particularly U. S. universities. Although this bill was not acted upon by the Congress, its basic concepts have been incorporated as an amendment to the Foreign Assistance Act of 1966.

The Amendment, under Section 211, reads as follows: "(d) Not to exceed $10 million of funds made available under Section 212, or under

Section 252 (other than loan funds), may be used for assistance, on such terms and conditions as the President may specify, to research and educational institutions in the United States for the purpose of strengthening their capacity to develop and carry out programs concerned with the economic and social development of less developed countries."

It is expected that the support to outside institutions will be through grants for the purpose of building long-range capability. The grants would be made in sufficiently large amounts to permit effective development of institutional resources. This will limit the number of grants that may be furnished initially but a few well funded centers will be more effective in achieving the goals of this provision of the Act than would numerous small enterprises scattered widely through many institutions.

It is recognized that new organizational arrangements in universities may be required to insure institutional commitments, and that the development of special curricula, the recruitment of career professors and graduate students guided to international development activities, and the establishment of special library facilities, will require long range planning and forward funding commitments.

The criteria for the selection of institutions to be supported are being developed and will include attention to (1) specific needs by the A.I.D. program which cannot be satisfied effectively by existing facilities or resources, (2) a commitment by the recipient institution to organize programs and faculty to guarantee a sustained effort in the area to be supported by the grant funds and to re-order curricula, recruit and train

personnel, and engage in research pertinent to A.I.D.'s program needs, (3) long range programs that envisage a time span of at least five to ten years that will insure stability of support for the universities and career opportunities for professors and graduate students, to stimulate them to apply their energies to such specialized program requirements, and (4) maximum flexibility for the university to exercise discretion in developing specialty competence within the broad limits required by the Agency.

The A.I.D. Administrator has assigned responsibility for development of this program to the Office of Technical Cooperation and Research. It is expected that an external advisory committee, representing various professional areas and broadly representative of universities, foundations, and other agencies that are most directly concerned with the Agency's program, will be established to help guide the Agency in its choice of recipients. The members of the committee would be selected for their individual capacity to contribute, however, rather than for institutional representation, and would be expected to furnish continuous guidance to the Administrator for this program.

In summary, we realize that the critical nature of the world-wide food and population problem has come into sharper focus during the past two years. There is an increased dedication on the part of U. S. government leadership to resolution of this problem.

There is a determined effort to build world-wide food production capacity through greater self-help and self-sufficiency in the food deficit nations.

Positive action has been taken to improve the U. S. resources and capability to meet this challenging international problem.

The goals for increasing world food supplies will not be achieved easily, and it will be essential to energize the cooperative world-wide agricultural development effort through new commitments for effective participation by the U. S. research and education institutions, and by the private industries that must furnish the essential guidance and leadership.

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FOOD AND PEOPLE -- THE WORLD

"World food production failed to rise in 1965-66, but population increased by about 70 million persons". This lead sentence in the news release of October 13 on the annual report of the Food and Agriculture Organization of the United Nations summarizes a condition that prompts FAO Director General B. R. Sen to state, "Any remaining complacency about the food and agriculture situation must surely have been dispelled by the events of the past year."

The stagnation of world food production in recent years, and the draw down on food grain reserves in surplus producing nations combine to call for hard decisions--as we realize that the population of the world will increase from 3.3 billion in 1965 to 6.8 billion by the year 2000 if the present birth rate of 2.1 percent per year is maintained for the balance of this century.

We are, of course, aware that nations differ widely in their rate of population increase. The most rapid population growth in the world is in Costa Rica. With a birth rate of 50 per thousand, a death rate of 8 per thousand, and a net population growth of 4.2 percent annually, Costa Rica's population will double in 16 years. In contrast, Hungary, with a birth rate of 13 per thousand, a death rate of 9 per thousand, and a net growth of 0.4 percent annually, would require 175 years for the national population to double.

Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Department of State, Agency for International Development, at the 43rd Annual Convention and Trade Show, the California Fertilizer Association, Ambassador Hotel, Los Angeles, California November 1, 1966

A.I.D.
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The relationship between population and food supplies is particularly critical in those developing nations where population growth rates are high and where food requirements will increase as economic and social development creates demands for improved diets. It will be essential to reduce birth rates and increase agricultural production if people and food supplies are to be brought into balance.

Substantial progress has been made during the past two years in gaining international attention to the need for population control. The U.S. government has adopted positive policies with respect to family planning, both in the U.S. and in foreign countries, and will now furnish assistance for family planning programs. The Agency for International Development has added specialists in this field, and officers for guiding population programs have been appointed also in the Departments of State and Health, Education and Welfare. Family planning programs have been initiated or expanded in many countries in Asia, Africa and Latin America in the past year.

We cannot expect an appreciable reduction in population growth over the next ten to fifteen years, but it is essential that effective nationwide programs be established promptly to help balance food supplies by the year 1985. Dr. Raymond Ewell, Vice President for Research of the State University of New York at Buffalo suggests, "After 1980 or 1985, birth control will have to become a major factor since improvement of agriculture cannot keep up with the present population growth rate beyond that time, no matter how optimistic one is about improving agriculture."

The World Food Budget

An excellent analysis of world food requirements, and potentials for production, has been developed by Dr. Quentin N. West of the Economic Research Service of the U.S. Department of Agriculture. This report, "World Food Needs", was published in February, 1966. Dr. West points out that food production in the less developed countries has increased by slightly more than 2 percent annually over the past 30 years, about the same rate as in the developed countries. Most of the increase in the LDC's, however, has been offset by expansion in population.

Projections of world food deficits have been made for the next two decades, under the assumption that there would be normal weather, no world-wide conflict, continuing economic growth, and a continuation of the current programs and policies effecting agriculture and trade--both in foreign countries and in the United States. If consumption were to be increased sufficiently in the food deficit countries to achieve minimum dietary standards it is estimated that the food grain deficit in the developing countries, which totaled about 16 million metric tons in 1966, would increase to 42 million metric tons in 1975, and to 88 million metric tons in 1985. The estimated 42 million ton gap ten years hence exceeds the total of one annual U.S. wheat crop. The 88 million ton shortfall in 1985 would be beyond the U.S. cropping capacity, even if we were to put back into production the 55 to 60 million acres now in reserve.

As President Johnson stated in his message to Congress on the foreign aid program on February 1, 1966, "We cannot meet the world food needs of the future, however willing we are to share our abundance, nor would it serve the common interest if we could. The solution is clear: an all out effort to enable the developing countries to supply their own food needs through their own production or through improved capacity to buy in the world market."

Production Goals in the Less Developed Nations

In order to reach desirable nutritional levels within the next decade, and to reduce imports, grain production in the food deficit nations must be accelerated from the current 2.6 percent annual increase to a 4.0 percent annual increase by 1975. There are, of course, differences of opinion with respect to the feasibility of achieving this goal. The recent study of 26 less developed nations, conducted by the Economic Research Service of the USDA, indicates that 12 have achieved an average annual increase of agricultural production of more than 4 percent during the years 1948-63.

However, the longer term average rate of production increase in both the less developed and developed nations during the past 30 years has been slightly more than 2 percent. This causes Dr. Raymond Ewell to suggest that, "It would be comforting if we could expect increases in agricultural production of 3 percent or more per year during the next decade, but the realistic outlook is that increases of 2 percent per year as an average of the underdeveloped areas are about as good as can be hoped

for." Dr. Ewell feels that countries that are basing economic plans on five percent per year increases in agricultural output are "deluding themselves into disaster."

The recent increased levels of production in the rapidly developing nations were achieved by changes in crop yields and by expanding arable or cropped lands. In the Philippines about 66.9 percent of the 5.2 percent annual increase in crop output was from added lands and only 9.8 percent from increased yields per acre. Similarly, the 4.2 percent annual increase in Brazil resulted from expanding cropped lands by 54.6 percent, with only 5.9 percent from increased yields per acre. Israel's 9.7 percent annual increase on the other hand, was the result of a striking 120.4 percent boost in crop yields and 68.5 percent increase in land area.

New Technology in Agricultural Development

It is recognized that only about ten percent of the world land surface is under cultivation at the present time. The problems and costs involved in developing more arable lands limit this source of increased agricultural production and encourage attention to increasing the yields per acre of present cultivated lands.

We have ample evidence of the possibilities for increasing food crop yields through the application of modern science and technology, including the use of fertilizers and improved pest control measures. Rice yields per acre in the southern U.S. have more than doubled during the past twenty years, from 18.6 bushels per acre in 1946 to 41.8 bushels in 1965. Wheat yields in Mexico have increased from a national average of 11 bushels per acre in 1943 to more than 39 bushels per acre in recent years.

These striking changes in productivity, as well as the similar advances in yields for many other crops in the U.S. have been achieved through integrated programs of research to breed and select disease resistant, high yielding varieties; improve soil fertility and water management practices; design more effective methods of disease, weed, and pest control; and to improve planting, tillage, and other cultivation practices.

The importance of science and technology in achieving agricultural progress in the United States and the need for application of this approach to international agricultural development is recognized in the amendment introduced by Senator Walter Mondale of Minnesota as Section 211(e) of the Foreign Assistance Act for 1966. This Amendment provides:

> "In any developing countries or areas where food production is not increasing enough to meet the demands of an expanding population, or diets are seriously deficient, a high priority shall be given to efforts to increase agricultural production, particularly the establishment or expansion of adaptive agricultural research programs designed to increase acre yields of the major food crops."

Agricultural scientists who have been working on food crop improvement research projects in tropical and subtropical regions for the past decade or more are convinced that acre yields can be doubled for wheat, rice, corn, sorghums, and millets in many of the food deficit nations within the next 5 to 10 years. Yield improvements of threefold or more over the local varieties have been achieved in the cooperating programs of the Rockefeller Foundation for one or more of these crops in Latin America, Asia and Africa.

The U.S.D.A. scientists who are cooperating with scientists in Nigeria, Uganda and Kenya under A.I.D. support have developed improved strains of sorghums and corn that yield 25 to 30 percent more than the local varieties. This research has been underway for only two years but where two or three generations can be grown annually in a crop breeding program, rapid progress is possible. More recently, hybrids developed from crosses between some of the better local varieties and a Central American variety of corn have produced yields 100 percent greater than the local varieties.

In adaptive research programs to boost acre yields, through the development of improved varieties with disease resistance and the capacity to utilize high levels of fertilizers, improved soil and water management practices, and effective control of pests and diseases, it is essential that these changes be maintained in balance. Fertilizers play an extremely important role, but advances in production through use of increased fertilizer materials alone will be limited.

In some instances applications of high levels of fertilizers may actually be detrimental. For example, in fertilizer trials with rice in East Pakistan, utilizing local rice varieties developed for the normal low levels of soil fertility, increased yields were obtained from nitrogen applications up to a level of approximately 40 pounds of nitrogen per acre; but substantially higher levels of nitrogen application actually caused a reduction in yields. Similarly, in India and Pakistan, many of the wheat varieties selected for growing on soils of normal low levels offertility will lodge and suffer losses in yield, along with poor grain development, when fertilized with more than 60 pounds of nitrogen per acre.

Farmers are well aware of the possible damaging effect of high fertility on yields of their common wheat and rice varieties. They will be reluctant to purchase and apply fertilizers where increases in yield are modest or where yields may actually be decreased. It is essential, therefore, that expanded use of fertilizers be linked closely to crop breeding programs for developing high fertility responsive varieties.

Adaptive Research for Wheat Improvement in Pakistan

One of the more exciting efforts now underway to increase the output of a major food grain on a nationwide basis is the improvement of wheat production in West Pakistan. This project, supported jointly by the Government of West Pakistan and the Ford Foundation, is based upon the high yielding dwarf wheats developed in Mexico through the cooperative research of the Rockefeller Foundation and the Government of Mexico.

Following preliminary tests, initiated in 1961 with the Mexican dwarf wheats Penjamo 62 and Lerma Rojo 64, which grow to about 30 to 40 inches in height, have stiff straw, and can convert large quantities of nitrogen and other plant nutrients into high yields without lodging, the West Pakistan government decided in June, 1965 to import 350 tons of seed of these wheats. It was recognized that plant diseases or insects not prevalent in Mexico might attack the imported wheats but it was believed that the danger of destructive disease epidemics could be minimized or overcome if Pakistan could develop promptly an effective breeding program to change varieties every two or three years.

The 350 tons of wheat seed arrived in the Karachi harbor on October 18, 1965, and through special orders from Governor Malik Amir Mohammad Khan giving the wheat shipment priority over all other cargo in the port, and making railroad cars immediately available during the national military emergency at that time, it was possible to place the seed stocks in the hands of private growers and on government seed farms throughout West Pakistan by November 1. About 2,500 private growers and 30 government research or seed farms participated in the project during the past year.

The 350 tons of seed imported from Mexico in 1965 were multiplied to about 17,000 tons of seed from the first harvest. It is expected that the production from the 500,000 acres to be grown during the current winter season will be about 600,000 tons, of which about half will be held for seed purposes. This will complete the multiplication of the two introduced varieties and it is expected that seed will be available for commercial planting in 1967 by all farmers who wish to grow these wheats.

The varieties introduced from Mexico are not fully acceptable to Pakistan consumers because of their red grain color. In recognition of this, a dwarf wheat with a white grain has been selected, tested, and is in the multiplication process. This variety, named Mexipak 65, was developed as a selection in Pakistan from an experimental cross made in Mexico. It is expected that by the autumn of 1968, after two years of intensive multiplication, the seed supply of Mexipak 65 should be adequate to replace the red-grained Lerma Rojo and Penjamo varieties.

In the extensive yield trials conducted at 90 locations throughout West Pakistan during 1965-66, most of which were on farmers' fields under normal cultivation practices, Mexipak 65 outyielded the most widely grown tall local wheat, C. 271, by more than 50 percent. This difference in yield prevailed on the high fertility soils, with fertilizer applications of 120-60-0; as well as on the average-fertility soils, with fertilizer levels of 60-60-0. The average yields for the 90 tests in West Pakistan were 37.8 maunds per acre for Mexipak 65; 33.6 maunds for Sonora 64; 32.8 for Lerma Rojo 64; 31.8 for Penjamo 62; and 24.7 for the commonly grown tall local variety, C. 271. (A maund is 82 pounds or 1-1/3 bushel.)

The yields in 1966 were lower than the potentials for the Mexican wheats because of lack of supplies of fertilizers in some areas and inadequate irrigation for many of the test plots. Highest yields were obtained by farmers who could supplement their irrigation from tube wells.

The dwarf varieties have completely changed the potential production in West Pakistan and also have furnished greater incentives to farmers to use higher levels of fertilizers on their wheat crop. The local tall varieties respond well to fertilizer levels of 60 pounds of nitrogen per acre, when P_2O_5 levels are adequate, while the dwarf wheats are more efficient and productive at applications of 80-40-0 to 140-40-0, depending upon base fertility levels and on cropping patterns.

Cost/benefit calculations show that the application of 92-40-0 on the dwarf wheats at the unsubsidized price for fertilizer in Pakistan would cost the farmer 96 rupees, against a return of 420 rupees, or a net profit of 324 rupees per acre. For every rupee spent for fertilizing the dwarf wheats, the return is about 4.50 rupees. Experience in Mexico and elsewhere suggests that where farmers obtain a 3.0 to 1 or 4.5 to 1 return on their investment in fertilizer the use of fertilizer increases rapidly.

There is a wide differential in the yield response of the dwarf wheats and the tall wheats to fertilizer in Pakistan. For every pound of fertilizer nutrient (both nitrogen and phosphate) the farmer applies, he obtains 17 pounds of increased grain from the dwarf wheats, as contrasted with eleven pounds from the local tall wheats. In Mexico, one pound of fertilizer nutrient applied to the commercial fields of dwarf wheat produced 23 to 28 pounds of increased grain, as contrasted with 14 to 16 pounds of increased grain from the local tall wheats in Mexico.

In addition to adaptive research to select the preferred white grain color, further studies will be required in Pakistan to determine optimum rates of fertilizer use. Other modifications required in growing the dwarf wheats in Pakistan included shallower planting (about 2 inches in contrast with 3 to 5 inches), higher rates of seeding, 5 to 6 irrigations during the season rather than 3 or 4, and harvesting 3 to 4 days prior to harvest of the tall wheats, to avoid shattering.

It is anticipated that if the program proceeds on schedule Pakistan will achieve self-sufficiency by 1970 and wheat production may be increased to a level that would permit exports to neighboring countries, or the release of wheat lands for production of other food and cash crops.

The advances in Pakistan also have a potential benefit throughout the region, with some of the improved wheats and breeding lines already in the hands of collaborating wheat breeders in Turkey, Iran, Afghanistan and India.

Guiding Fertilizer Use in Developing Nations

The increased use of fertilizers has made a profound contribution in the United States, where crop output per acre has increased by more than 50 percent since 1940. The importance of fertilizers in other countries also is fully apparent. Japan, the only country in Asia where diets are adequate, uses over 250 pounds of plant nutrients per acre. This is in sharp contrast to India where the level is less than four pounds of plant nutrients per acre.

It is estimated that if the total food production that is needed by 1980 is to be obtained, the use of fertilizers in Asia must be expanded from 3 million metric tons of plant nutrients to almost 30 million tons, in Latin America from 1 million tons to 4 million, and in Africa from 1 million to 3 million.

In order to provide more precise information on the nutrient status of soils, on the response of crops to fertilizers, and to build soil testing capability of local institutions in Latin America, North

Carolina State University, under A.I.D. support, has been conducting a soil testing program throughout the region. The U.S. scientists are working in Brazil, Costa Rica, Guatamala and Peru, with collaboration in other countries.

As a result of this cooperative effort, model soils laboratories have been established in 16 countries. Testing procedures have been standardized, plant responses to fertilizers are being determined, and training programs are underway for local personnel. In addition to guiding the development of the national laboratory facilities, collaboration has been stimulated among the countries. It is expected that the experience from this study may be readily adapted to other tropical and semitropical areas where the analytical models of the Latin American project will enable other countries to map their soil fertility status and fertilizer requirements with much greater precision.

Another study supported by the Agency for International Development was conducted by the Tennessee Valley Authority, to estimate planned world fertilizer production capacity as related to future needs. The TVA report of February, 1966, is based on about 100 interviews with industrial and planning organizations in North America, Europe and Japan, supplemented by extensive correspondence and various publications as sources of information. A.I.D. expects to maintain a close working relationship with the TVA in order to develop continuing assessments of the world fertilizer supply and demand situation.

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Foreign Investment Opportunities

The Agency for International Development provides a wide range of services to stimulate private investment in productive enterprises, and is particularly eager to encourage their use for enterprises related to the War on Hunger. The brochure AIDS TO BUSINESS (OVERSEAS INVESTMENT), available from A.I.D.'s Office of Development Finance and Private Enterprise, outlines the types of assistance that can be provided.

The Catalog of Investment Information and Opportunities makes available technical and economic studies regarding food production, processing, and marketing activities in developing countries. A.I.D. can pay 50 percent of the cost of a prospective investor's own survey of an investment opportunity, if no investment results.

Specific risk investment guarantees offer protection against the risks of (1) inconvertibility of foreign currency, (2) loss from expropriation or confiscation, and (3) loss due to war, revolution or insurrection. Extended risk guarantees are available to cover up to 75 percent of an investment against both political and business risks. (In recent months, A.I.D. has authorized both specific and extended risk guarantees on two fertilizer projects, one in Brazil and one in India. The investment in each project will total approximately $70 million.)

The "Cooley" loan program makes local currencies available to private American firms for financing such local costs as the expansion of plant and equipment, acquisition of land, training, and operating

costs. Dollar funds can also be made available, primarily through re-lending by A.I.D.-assisted intermediate credit institutions in the developing countries.

During the past 20 years, U.S. agencies have provided about one billion dollars for developing countries for fertilizer imports, and more than 100 million dollars for construction of fertilizer plants. It will be essential for private industry to increase investments still further to establish the expanded fertilizer industries that will be required abroad.

A.I.D. is prepared to work closely with private companies in helping to identify and remove restrictive factors and to facilitate more active participation in the international War on Hunger that looms as the major challenge in our foreign aid efforts for the balance of this century.

References

1. Ewell, Raymond. "Population Growth and Birth Control." Journal of International Health, Volume 2. No. 1. Fall, 1966

2. West, Quentin M. "World Food Needs." Economic Research Service, U. S. Department of Agriculture. February, 1966

3. "Changes in Agriculture in 26 Developing Nations, 1948 to 1963." Economic Research Service, FAER 27, U. S. Department of Agriculture, November, 1965

4. Huffman, Donald C. "Proceedings of the Southwestern Conference on The World Population Explosion and Its Implications for Agriculture and the South." Louisiana State University, Baton Rouge, Louisiana. April, 1966

5. Narvaez, Ignacio, and Qureshi, S. A. Annual Technical Report, Accelerated Wheat Improvement Program, West Pakistan, 1965-66 Agriculture Department, Government of West Pakistan, Lahore August, 1966.

6. "Estimated World Fertilizer Production Capacity as Related to Future Needs." Tennessee Valley Authority, Muscle Shoals, Alabama. February, 1966

Frontiers for Agricultural Research to Meet U. S. and World Needs: Frontiers and Needs, Internationally

A paper for a general session of a professional society meeting presents interesting alternatives -- to explore specific issues in the specialized field -- or to furnish a diversion from the heavy diet of scientific interchanges. While I retain some "sense of belonging" among agricultural engineers by virtue of associations developed more than a decade ago through the U.S.D.A.'s Bureau of Plant Industry, Soils, and Agricultural Engineering, I shall respect the factual non-professional engineer image and focus on some aspects of science and technology in the foreign aid program.

We have been cooperating with many nations in development efforts for a substantial span of years and perhaps some assessment or stock-taking may be in order.

The increasing worldwide concern over the relationship between population growth and food supplies has added new dimensions to our foreign relations. President Johnson, in August of 1965, said of the population explosion, "Second only to the search for peace, it is humanity's greatest challenge". In his message on the Food for Peace Bill last February 10 the President proposed "that the United States lead the world in a war against hunger".

Although we have added emphasis in the past year on international cooperation in agriculture, such cooperation is not a phenomenon of our generation. In 1871

Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, at the 1966 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 9, 1966

Horace Capron, the United States Commissioner of Agriculture, furnished a technical assistance staff to help establish experimental farms and a college of agriculture in Japan, to guide the agricultural development of Hokkaido. This venture preceded the passage of the Hatch Act of 1887 establishing the agricultural experiment stations of our Land-Grant Universities.

International collaboration in agriculture has been of substantial mutual benefit. It has been estimated that about one-half of our gross national product in agriculture comes from materials introduced from abroad, including strains of hard red winter wheat from Turkey and Russia, long staple cotton from Egypt, soybeans from China, and alfalfa from Siberia. During World War II joint research and development projects undertaken with other countries in the Western Hemisphere helped to insure essential supplies of rubber, Manila hemp, quinine, and insecticidal materials.

The Marshall Plan, authorized under the Foreign Assistance Act on April 3, 1948 was a subsequent high-intensity cooperative effort that successfully accelerated the recovery of the countries of Western Europe. Our agricultural trade has been enhanced in recent years as a result of this collaboration.

Many of us heard President Truman's inaugural address of January 20, 1949, and his fourth point, "We must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas." President Truman clearly identified the significance of science and technology, or technical assistance, as he stated, "The United States is preeminent among nations in the development of industrial and scientific techniques. The material resources which we can

afford to use for the assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible."

The Department of State was given the responsibility on January 27, 1949 for planning Point IV programs, but the enabling legislation, the Act for International Development, Public Law 535, was not passed by the Congress and approved by the President until June 5, 1950.

Shifting Frontiers in International Development

We have had 16 years of cooperative effort in improvement of the developing nations of Asia, Latin America, and Africa -- countries that have been described as poor, tropical, and agricultural. Our lack of familiarity with tropical agriculture has made this a pioneering effort, with a wide spectrum of new frontiers.

The lack of adequate progress in agricultural development during this period is reflected in the opening sentence of the news release of October 13, 1966 of the Annual Report of the Food and Agriculture Organization which stated, "World food production failed to rise in 1965-66, but population increased by about 70 million persons." Director-General B. R. Sen of the FAO, states in this report, "Any remaining complacency about the food and agriculture situation must surely have been dispelled by the events of the past year."

The early years of the Point IV program were marked by a number of factors that influenced the rate of progress in the agricultural sector. These include (1) the emphasis on industry versus agriculture, (2) the "extension bias" versus research, and (3) the emphasis on crash programs rather than long range or sustained efforts.

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Agriculture and Industry

The impatience to industrialize caused government leaders of a number of newly independent nations to shift, prematurely, their major financial and human resources to industrial development. The failure to recognize the importance of a solid agricultural base for economic development has special significance in India where, in spite of the need for special efforts in a "Grow More Food Campaign" in 1950, the Indian Government decided in 1955 that the country's food problem was solved and so major emphasis was placed on industrial development in the second five-year plan.

The neglect of agricultural development in India is reflected in the need of that nation to import approximately one million tons of food grains per month over the past year. Similarly, the lack of sufficient attention to agricultural research is reflected in India's importation of agricultural technology from abroad in the form of the high yielding rice varieties from Taiwan and the high yielding wheat varieties from Mexico. The purchase of 18,000 tons of seed of the Mexican wheats by India in August of 1966 is the largest massive international shipment of a seed stock of a major food grain in history.

Extension and Research

The "extension bias" of our foreign aid efforts of the past 16 years reflects the basic concept during the early days of the Point IV program that the major thrust in this program should be "the export of U. S. know-how." Perhaps this reflects a strict literal interpretation of President Truman's Point IV statement, "I believe that we should make available to peace-loving

peoples the benefits of our store of technical knowledge in order to help them realize their aspirations for a better life."

During the interim period, following the inaugural message and the enactment of the Point IV legislation, the U. S. Department of Agriculture sent, on January 27, 1950, a team of three specialists on a 90 day trip through 12 Eastern Hemisphere countries which had requested the services of U. S. technicians under the more limited technical cooperation authority of Public Law 402. As recorded in the U.S.D.A. report on "A Century of Technical Assistance to Other Nations", this initial Point IV team returned from the discussions with foreign government leaders "with preliminary plans for cooperation with Iran in development of agricultural extension and research, cooperation with Ceylon in an agricultural extension program to increase the efficiency of rice production, and cooperation with Pakistan in improving agricultural extension work".

The emphasis on extension in the recommendations of this first Point IV team reflects, as suggested by Dr. John Mellor of Cornell University, who has spent considerable time overseas and who was writing from India, "the tendency among foreigners (U. S. specialists) as a group -- to err in over-estimating the present state of science and technology in South Asia as it bears on agricultural development." Dr. Mellor concludes also that "foreign technicians who come for short periods of time, or who work primarily in consulting roles, tend to be much more certain that there is a major stock of unapplied technology than do foreign technicians who have stayed for a long time in a working capacity."

The early miscalculation of the adequacy of agricultural science and technology in Asia is reflected particularly in the case of Pakistan where the first survey team, in March of 1950, determined that emphasis should be placed on a cooperative extension program as a means of improving Pakistan agriculture.

Crash Programs Versus Sustained Efforts

The continuous attempts to remedy food production deficits through a series of crash programs find us in 1966, after 16 years of international cooperation, with the indigenous "self-help" capability for agricultural production improved very little over the situation that prevailed in many of the developing nations in 1950. In his discussion of the world food crisis at the annual meeting of the Land-Grant College Association last month, Dr. F. F. Hill of the Ford Foundation, stated, "We have been and still are in the overseas technical assistance business on a long-term basis, even though we are not organized on this basis, financially or otherwise. In any case, if we hope to achieve solid results on the research front, everyone in this room knows from experience that projects must be organized on a long-term basis."

With reference to the importance of sustained professional effort, Dr. Hill pointed out, "No Land-Grant Institution in a wheat growing state in this country would think of undertaking a wheat improvement program with a staff consisting wholly or in large part of persons on two-year assignments from the Rothamstead Experiment Station (in England). It simply would not work, and we know it. Neither are short-term consultants, no matter how knowledgeable and distinguished, a substitute for qualified professionals who stay on the job year in and year out."

The annual authorization for the foreign aid program, the lack of willingness on the part of some administrators of both donor and recipient nations or organizations to initiate long term programs, and the shortage of professional personnel in the U. S. institutions that are depended upon to conduct

the cooperating activities, have all combined to handicap establishment of the long range programs that are essential in building self-help capability for agricultural progress.

The shortage of qualified agricultural personnel in U. S. institutions is clearly evident from the number of positions that are unfilled in the A.I.D./U.S. university contracts for foreign cooperation, and the number of such positions that are filled through recruitment of staff members outside of the contracting U. S. university. In recognition of this general situation, an amendment included as Section 211(d) of the Foreign Assistance Act of 1966, provides,

> "Not to exceed $10 million of funds made available under Section 211, or under Section 252 (other than loan funds), may be used for assistance, on such terms and conditions as the President may specify, to research and educational institutions in the United States for the purpose of strengthening their capacity to develop and carry out programs concerned with the economic and social development of less developed countries."

The changes in emphasis in the foreign assistance program during recent years, as reflected in the Mondale Amendment for adaptive research, and in the Section 211(d) authority to build long term institutional capability, are important constructive forces for mounting a more effective worldwide "War on Hunger". These potentially valuable instruments have been rendered largely ineffective, however, by the substantial reductions in the technical cooperation budget of the foreign aid program for fiscal year 1967.

It will be essential to have reasonable assurance of budgetary stability if we are to develop the long range programs that are necessary for effective research and development in international agriculture. We cannot expect U. S. research and educational institutions or capable U. S. agricultural scientists to

make firm, long-term commitments to international programs in technical assistance without equally dependable commitments from their Government.

Accelerating Agricultural Development

The concerted efforts to increase food production in recent years have included special attention to the production inputs from outside of agriculture, from "off the farm", such as fertilizers and pesticides. New agricultural technology also is being used, particularly food crop varieties capable of utilizing high levels of nitrogen fertilizer to produce yields that are double to fourfold those of commonly grown local varieties. It is, of course, necessary to modify agronomic and biological introductions from foreign sources to suit them to new and variable soil and climatic conditions. In the case of engineering applications for agriculture, we also have a substantial background of information or principles that may be adapted.

Land Development

In many parts of the world most of the arable land is already in use and increasing yields per acre is the only alternative for expanding production. However, there are still millions of acres of uncultivated land which offer potentials for cropping and the engineer will play an important part in getting these areas into economic production. Some of these are saline or waterlogged; some require an economic source of irrigation water; some need drainage; and some lack access or transportation.

The largest areas of underdeveloped arable lands are in the tropics. One of the major limitations to their use, particularly where rainfall is high, is the cost of clearing. Conventional hand methods may cost as much as $500 per

acre but recent experience in Costa Rica, in which four U. S. private companies participated, demonstrated that tropical rain forest areas can be cleared for colonization for as little as $50 an acre, utilizing modern heavy equipment. The Government of Costa Rica is now considering a special agricultural development program utilizing these land clearing methods.

Irrigation and Drainage

Agricultural production in many regions of the world is limited by the lack of understanding of evapotranspiration and the salinity and drainage problems associated with poorly designed irrigation projects. In the Near East and South Asia little progress can be made in agricultural development in certain areas until soil and water management practices are improved. As an example, the Punjab region of India and Pakistan, the Indus Basin, contains the largest body of irrigated land in the world, about 23 million acres. The irrigation system has developed over many centuries without the benefit of modern planning. The lack of an artificial drainage system, to supplement the natural drainage of the area, has caused the buildup of the ground water table over the past 50 to 100 years. In addition, the continuous deposition of salts from the evaporated and transpired water applied to the soil has caused a broad-scale accumulation of salinity in the soil. Large tracts of land have been virtually destroyed and much of the soil productivity has been seriously impaired.

The U. S. foreign aid program, through the Department of Interior, furnished assistance in identifying the principal components of this long standing problem in the "waterlogged" area of Pakistan. The high ground water table is,

of course, one important element, as is the spreading of too little water (some 60 percent of optimum) over too much land area. This limited irrigation does not support maximum crop production and fails to flush out the salt buildup that results in gradual deterioration of the soils.

The basic solution was the installation of large capacity turbine pumps (3 - 6 cusecs capacity) on a density of about one per square mile. This tube well system is carefully coordinated with the surface canal system.

Approximately 2 million acres of the 23 million acres in the region have been so treated and plans are ready for an additional 2 million acres. The first project was initiated in 1961 and the last of the wells were put into operation in 1963. The water level had been lowered more than 8 feet on an average by October, 1965 and over 247,000 acres reclaimed out of 525,000 acres that were wholly or partly affected by waterlogging and salinity.

Storage Facilities

These land clearing and irrigation and drainage projects for land reclamation were based on the application or adaptation of experience from the U. S. There are, of course, many other problems in agricultural development and modernization that would benefit from the application of modern engineering. It is estimated, for example, that losses of food grains in India range from 15 to 25 percent because of primitive harvesting and storage practices and attacks by insect pests, rodents and birds. Storages in underground pits, mud-walled structures, or bamboo and straw bins are inadequate and the U. S. alternatives of aluminum or steel bins are too costly for most Indian villagers.

Farm Power and Machinery

Another major challenge is the development of improved machines for increasing agricultural production. The primary objective of mechanization in most of the developing nations is not to save labor, since 50 to 75 percent of the people are on the land, but rather to expedite time-consuming farm operations to limit the period of idleness of land and return soil resources to productive use in the shortest possible time. The goal is to achieve maximum production per unit of land, per day or per year.

In studies in West Pakistan, it was found that a farmer with one pair of bullocks can take care of about twelve and one-half acres of irrigated, single-crop land. The farmers actually require more time of their bullocks in threshing grain than they do in the rest of their field operations. The introduction of field threshing machines allowed the farmers to either double-crop their twelve and one-half acres, or to farm about twenty acres on a single-crop basis.

Dr. Richard Bradfield, Professor Emeritus of Cornell University, who is now located at the International Rice Research Institute at Los Banos, the Philippines, is studying new rotations using varieties of crops that are short season, i.e., that require a minimum number of days from planting to harvest. He is including rice, sweet potatoes, sweet corn, soybeans, and sorghums in these studies, with crop sequences planned for minimum tillage, for direct seeding of rice to limit time and labor inputs, and the identification of tasks such as land preparation and harvesting that require a high power input to achieve minimum turn-around time.

A companion to this agronomic research is the study on engineering and economic aspects of mechanization, conducted by the Institute and supported by A.I.D. The purpose of this project is to develop power sources and equipment suitable for work in rice and related crops; to compare alternative power sources with respect to costs and benefits; and to determine the impact of mechanization on farm organization and cropping patterns. Power equipment will be designed to achieve maximum efficiency for various cropping sequences, with attention to such improved farm organization factors as size and shape of fields best suited for efficient cropping, soil and water management, power use, and maximum economic returns.

Mr. Lloyd Johnson, Agricultural Engineer of the International Rice Research Institute has suggested that the specially designed 5 to 9 horsepower Japanese power tillers that are now increasingly available in the rice bowl countries could reduce substantially the cost of land preparation if the units were used on a contractor basis for over 1,000 hours per year. He predicts that the larger power units, including the experimental 72 horsepower tandem tractor that has been tested at the Institute should prove even more attractive for contractor or custom operations in the rice bowl countries.

Another study on the size of power units in small farm agriculture is under way in the Bombana settlement project, about 40 miles from Morioka City on the Island of Honshu, Japan. This project includes about 3,000 hectares that were taken over by the Government from wealthy Japanese industrialists following World War II, for settlement of repatriots from Manchuria and migrants

from Southern Japan. A broad gauge research program, including studies of soil management, agronomic practices, cropping systems, etc., is under way, in addition to the evaluation of power units. The major objective is the reduction of labor costs for dairy and livestock enterprises and for producing a variety of cash crops.

In the study, a medium sized tractor, of 35 horsepower, is furnished for ten of the families. A small tractor, a Farmall Cub, furnishes the power for three families. Additional farms are powered with horses or bullocks. On the basis of the results of the first few years the larger tractor appears to be most efficient because of (1) the smaller initial cost per family, (2) the reduced operating costs made possible through use of diesel fuel, and (3) the more effective performance for plowing and other high-power-requiring jobs.

The farmers on the larger land areas, from five to ten hectares, are developing satisfactory farming enterprises, but those on the higher slopes, or with horsedrawn equipment, have been seeking jobs in the urban areas and abandoning their farms.

Engineering Applied to Agricultural Requirements

Agricultural engineers have made an outstanding contribution to U. S. agriculture by standing firm in the conviction that machines and facilities should be designed, through well-focused research and development, for precision suitability to the needs of agriculture. This was exemplified by the late Arthur W. Turner when he served as Director of Agricultural Engineering Research in the U. S. Department of Agriculture in the 1940s. In a series of conferences with government and industry officials who

encouraged studies to determine how the surplus jeeps from World War II might be utilized on U. S. farms, Art Turner took the position that the jeep was not designed to furnish efficient power, or to serve essential transport functions on most American farms. He felt that encouragement of farmer investments in such ill-suited machines would detract from progress in the more effective mechanization of agriculture. That judgment, shared by many of you, has helped to accelerate the type of research and development in engineering that has contributed immeasurably to increasing productivity and efficiency in all aspects of the agricultural industry in this country.

We must assess, similarly, the needs of the traditional farms and farmers in Asia, Latin America, and Africa, and design equipment and facilities specifically to meet their needs.

Building Research and Engineering Institutions

If we are to achieve the doubling of food production, or the increases of even greater magnitude that are predicted as required by the end of this century, we cannot depend only upon the immediate or "crash" inputs of improved crop varieties and production practices, expanded use of fertilizers and pest control materials, and improved machines and facilities designed through the application of engineering principles. We must also assist in establishing the types of research and education institutions in the developing nations that will provide a sustained flow of new technology suited for specific soil, climatic and social environments. This can be accomplished in part through the collaboration of U. S. universities, as has been done through A.I.D. support in India where the College of Agricultural Engineering has been established

at the Indian Institute of Technology at Kharagpur in West Bengal; where the University of Illinois is assisting in developing the Agricultural Engineering College at the Uttar Pradesh Agricultural University; and where Ohio State is helping to develop a College of Agricultural Engineering at the Punjab Agricultural University.

The Rockefeller Foundation has supported some of these activities, as has the Ford Foundation. The latter has furnished funds also for a machine shop associated with the Allahabad Agricultural Institute which is designing and producing simple small equipment such as steel plows, seeders, and hand cultivators.

International organizations are assisting in the development of agricultural engineering centers and one that has achieved marked progress is located on the campus of the Agrarian University near Lima, Peru, for which Dean Roy Bainer of the University of California has served as a consultant.

I believe that a major impact in the modernization of agriculture in developing countries can be made by the more active participation of private industries in research and development activities. Their experience in engineering development for a wide variety of applications in U. S. agriculture should insure rapid progress in similar endeavors overseas. The close coordination of efforts of engineers with those of agronomists and other agricultural scientists in the emerging research and education centers in developing nations should expedite the modernization and improved productivity of agriculture abroad.

In closing, I suggest we reflect seriously again on the words of the 1949

Point IV message, "Our aim should be to help the free peoples of the world, through their own efforts, to produce more food, more clothing, more materials for housing, and more mechanical power to lighten their burdens." We recognize, in that message, the clear-cut and distinct challenge to agricultural engineers. We recognize also the inadequacy of our accomplishments during the intervening 17 years, a realization that has prompted President Johnson to call for a new initiative and more intensive effort in achieving these foreign aid objectives.

References

1. Drosdoff, Matthew. "A Century of Technical Assistance to Other Nations." International Agricultural Development Service, U. S. Department of Agriculture, November, 1966

2. Hill, F. F. "U. S. Land-Grant Colleges and the World Food Crisis: A Suggested Program of Action". Annual Meeting of the Land-Grant College Association, Washington, D. C., November 15, 1966

3. Johnson, Lloyd. "Is Mechanization Possible Where Rice is King?" Agricultural Engineering, Vol. 47, No. 3, March, 1966

4. Mellor, John W. "The Crucial Role of Science and Changing Technology in Agricultural Development." Conference on Science and Society in South Asia, Rockefeller University, New York City, May 2 - 4, 1966

5. Traywick, J. D. "India Challenges Agricultural Engineers." Transactions of the ASAE, Vol. 9, No. 2, 1966

World Food Production Prospects and Potentials: A Short Run Look

A major question posed for those of us who accept invitations to speculate on world food production potentials is: "How critical is the crisis?". We look ahead today from a different base point from that of only one or two years ago when we were preoccupied with crop surpluses and less alert to prospects of inadequate world-wide reserves of food grains.

Judgments today reflect serious concern not only about long term food needs but also the near term threat of massive starvation in some Asian countries unless there is a vast step-up in the use of essential agricultural inputs including new technology and more fertilizers. Dr. Raymond Ewell, Vice President for Research at the State University of New York at Buffalo, foresees "deep trouble" for India by 1970 or 1971. He points out that the forthcoming harvest will be of about the same magnitude as that of 1960. In the six intervening years 75 million people have been added to the population. He further points out that in less than 15 years, with its present birth rate, India will add another 200 million people. The United States, with all of its advances in agriculture, would be hard pressed to feed 200 million additional people by 1981.

The projections of the Food and Agriculture Organization of the United Nations do not focus so sharply on a near term crisis, but the

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the Symposium on Alternatives for Balancing Future World Food Production and Needs, Iowa State University, Ames, Iowa
November 9, 1966

message is clear, with world population increased by 70 million during the past year and world per capita food supplies down by four to five percent.

As we address the subject of "the short run look", it is essential to recognize that the food problem is a continuing and escalating one. We have passed the stage where we can perpetuate the crash effort syndrome, with emergency measures to take care of today's needs and a hope that tomorrow will take care of itself.

The short run, therefore, should be concerned not only with enhanced efforts to meet today's requirements but also with those steps to be taken immediately to build the base for expanding requirements ahead. With this in mind, the subjects selected for discussion in the short run context include (1) Food for Peace adjustments to produce for world needs, (2) measures to increase production in the food deficit nations, (3) building self-help capability in the developing nations, (4) strengthening domestic capability for more effective international cooperation for the War on Hunger, and (5) some basic issues for U. S. decision makers.

Food for Peace, 1966

The basic objective of the PL 480 program has been modified this year from the disposal of U. S. surpluses to the guided increase in domestic production to meet world food needs. Under Secretary of Agriculture John A. Schnittker, will discuss tomorrow the capacity of the United States to supply

quantities of foods for export. A glance at current projections is in order, however, to furnish the framework for our short run look.

The U.S.D.A. has estimated that the food grain deficit in the developing countries that totals about 16 million metric tons this year will increase to 42 million metric tons in 1975 and to 88 million metric tons by 1985. This assumes that there would be normal weather, no world-wide conflict, continuing economic growth, a continuation of the current programs and policies affecting agriculture and trade, and consumption increased sufficiently in food grain deficit nations to achieve minimum dietary standards.

The 88 million metric ton shortfall in 1985 could not be met by the total U. S. cropping capacity, even if we were to restore the more than 50 million acres now in reserve. As an example, approximately 16 million acres have been restored to wheat production this year. It is expected that this will boost the harvest to 1.6 billion bushels as contrasted with the 1.2 billion expected from the current year's crop. If we accept the estimates that world demands for wheat are increasing at the rate of 300 million bushels each year, the restoration of 30 percent of our reserve crop lands will make only a relatively short term impact on the expanding world requirements.

One element still to be assessed in determining the real capacity of the U. S. and other food surplus nations to contribute to world requirements is the more effective application of new technology.

Rice yields per acre in the southern U. S. have more than doubled during the past 20 years, from ~~18.6~~ 38.5 bushels per acre in 1946 to ~~41.8~~ 81.7 bushels in 1965. We are aware of the astonishing yield increases achieved through research in wheat breeding and on agronomic practices in the Pacific Northwest, with the short strawed "Gaines" variety which was selected from hybrids involving the "Norin" wheats introduced from Japan following World War II. Through adjustments in soil fertility and water management, "Gaines" has produced yields under field conditions that have moved from 133 bushels per acre in 1962 to 167 bushels in 1963, 190 bushels in 1964, 209 bushels in 1965, and 216 bushels in 1966.

The yields of "Gaines" wheat furnish some evidence of what the biological potentials might be for increasing food production. We still need substantial research, however, to determine the economic and agronomic feasibility for achieving such production on large acreages in the U. S. and abroad.

Regardless of the technological feasibility of producing substantially increased quantities of food grains in the advanced nations, we must recognize the economic and social limits for continued importations by the food deficit countries. Repayment burdens from dollar sales, or excessive accumulations of local currencies will increase political tensions with nations striving for new freedoms.

We will face continuing careful and difficult adjustments in production of wheat and other food grains in the United States in the next decade, to coordinate with cropping changes in Canada, Western Europe, and

Oceania, as well as in Eastern Europe and the U.S.S.R., that will be designed to meet the gradually growing requirements of the diet deficit regions.

Increasing Production in Food Deficit Nations

President Johnson, in his message to Congress on the Foreign Aid Program on February 1, 1966, stated, "The problem of hunger is a continuing crisis. In many parts of the world we witness both the ravages of famine born of natural disaster and the failure of food production to keep pace with rising needs.

"We cannot meet the world food needs of the future, however willing we are to share our abundance. Nor would it serve the common interest if we could.

"The solution is clear: an all out effort to enable the developing countries to supply their own food needs through their own production or through improved capacity to buy in the world market."

Section 103 of Title I of the Food for Peace Act of 1966 specifies that, "In exercising the authorities conferred upon him by this title, the President shall -- (a) take into account efforts of friendly countries to help themselves toward a greater degree of self-relience, including efforts to meet their problems of food production and population growth."

The prospects for increasing food grain production and for growth in the agricultural sector of the developing nations require serious and sober analyses. There is a tendency to speak glibly about growth rates of five to seven percent, and even higher, as we review development plans of

cooperating nations. In making projections, we should keep in mind that the highest yield increases recorded over a 24 year period (1935-39 to 1960-62), have been the 3.7 percent annually for corn in the United States, the 3.3 percent for wheat in Mexico, and the 1.9 percent for rice in the United States.

The high growth rate in agricultural productivity in Taiwan is frequently cited as a reason for optimism. Taiwan did achieve agricultural production increases averaging 4.4 percent annually in the post war period, with crop yields per acre also advancing at near this level. Taiwan, however, had a strong base of science and technology for a quarter of a century prior to World War II and during this period developed new strains of rice adapted to its climate, capable of producing high yields with high levels of nitrogen fertilizer. This technology was a major building block in the post war progress in Taiwan. Evidence of the value of this basic input is the importance of the variety Taichung Native 1 in the plans for increasing rice production in India and Pakistan. This variety, with heavy fertilization, is expected to have a major impact on meeting the rice needs of these countries in the next five years. Similarly, India and Pakistan are depending heavily upon the "Mexican wheats" which also have the capacity to produce high yields under heavy fertilization, and have been responsible for increasing wheat yields in Mexico from approximately 11 bushels per acre in 1943 to 39 bushels per acre as a national average in recent years.

The concerted effort to increase wheat production in West Pakistan is a cooperative venture supported by the Government of West Pakistan and the Ford Foundation. This project is based upon the high yielding Mexican wheat varieties Penjamo 62 and Lerma Rojo 64 that were developed through the cooperative research of the Rockefeller Foundation and the Government of Mexico. These varieties include the same Japanese "Norin" germ plasm as the U. S. variety "Gaines". They grow to about 30 to 40 inches in height, have stiff straw, utilize large quantities of nitrogen and other plant nutrients to produce high yields without lodging, and performed well in yield trials initiated in Pakistan in 1961. The West Pakistan Government decided in June 1965 to import 350 tons of seed of these wheats from Mexico and it is expected that the 600,000 tons of grain from the current winter season crop will be sufficient for commercial planting by all of the farmers who wish to produce these wheats in West Pakistan.

The varieties introduced from Mexico are not fully acceptable to Pakistan consumers because of their red grain color. In recognition of this, a dwarf wheat with a white grain has been selected, tested, and is in the multiplication process. This variety, named Mexipak 65, was developed as a selection in Pakistan from an experimental cross made in Mexico. It is expected that by the autumn of 1968, after two years of intensive multiplication, the seed supply of Mexipak 65 should be adequate to replace the red-grained Lerma Rojo and Penjamo varieties.

Other modifications required in growing the dwarf wheats in Pakistan include shallower planting (about 2 inches in contrast with 3 to

5 inches), higher rates of seeding, 5 to 6 irrigations during the season rather than 3 or 4, and harvesting 3 to 4 days prior to harvest of the tall wheats, to avoid shattering. Further studies will be required to determine optimum rates of fertilizer use.

The objective of this cooperative wheat production program is to double the wheat yields in West Pakistan by 1970 and the results of the first two years of this effort suggest that this goal may not be out of reach.

Building Self-Help Capability

The short run transfers of the high-yield capabilities of wheats from Mexico or Washington State, or of rice varieties from Taiwan must be accompanied by intensive applied research to adapt these materials to the variable environments in tropical and subtropical food deficit nations. Administrative and political leaders of developing countries must be made aware of the sustained effort required to protect the "improved seeds" from constantly changing hazards of new virulent and destructive races of diseases or insect pests.

Under the emergency situations confronting nations with rapidly growing national food deficits, and where they have neglected to support agricultural science and technology at adequate levels in past decades, the borrowing of technology from abroad is essential. At the same time, it is equally essential to recognize the catastrophe that may accompany the blind faith in such "improved seeds" as continuing solutions. These nations must take steps immediately, in the short run, to build the indigenous capability to meet the biological hazards that will be changing

even more rapidly as agricultural production is intensified with introduced crop germ plasm and heavy applications of fertilizers.

The U. S. farmer could not depend upon the scientific capability of a foreign nation to resolve the series of hazards that have confronted our production, including races of rusts and smuts which have attacked wheat and small grains throughout this country, the corn borer and other insects that have reduced yields of the corn crop, and the different virus diseases which have threatened cereal grain production continuously. Neither can the farmers of Asia, Africa, or Latin America continue to be dependent upon foreign technology.

The amendment to the Foreign Assistance Act of 1966, introduced by Senator Mondale of Minnesota as Section 211(e), recognizes the importance of applied or adaptive research in building food production capability in the developing nations. This amendment states:

> "In any developing countries or areas where food production is not increasing enough to meet the demands of an expanding population, or diets are seriously deficient, a high priority shall be given to efforts to increase agricultural production, particularly the establishment or expansion of adaptive agricultural research programs designed to increase acre-yields of the major food crops.
>
> "Such research programs, to the greatest extent possible, should be based on cooperative undertakings between universities and research institutions in the developing countries and United States universities and research institutions."

It is essential that we recognize the importance of <u>sustained effort</u> in building institutional capability in the developing countries. Dr. T. W. Schultz of the University of Chicago, in his presentation to

the Committee on Agriculture of the House of Representatives on February 18, 1966, referred to the inadequate attention that has been given to the development of viable agricultural research centers in U. S. cooperation in agriculture abroad. As stated by Dr. Schultz, "After two decades, starting with the Point Four programs when about a third of the aid funds for Latin America were allocated to agricultural development, and large amounts since then, there is not a single first class agricultural research center in Latin America to show for it. Why? Latin American governments have not vetoed such research. The reasons are predominantly of our own making; namely, (1) crash programs, (2) the agricultural extension bias, and (3) selling agriculture short in economic development, especially after the Point Four period."

We are well aware that it is not possible to develop research or other agricultural institutions through short term projects, or by transient specialists--whether they be direct-hire A.I.D. employees, from universities, or from private agencies that rotate assignments every two, four, or six years.

Institution building for agricultural development can be achieved in developing nations through a sustained effort as has been demonstrated by the adaptive research programs of the Rockefeller Foundation which furnished the base for the agricultural center at Chapingo, Mexico and the Colombian Institute of Agriculture which will provide nation-wide systems of agricultural research, education and extension. The Foundation

cooperation also guided the restructuring of the Indian Council of Agricultural Research that is furnishing national leadership for coordinated crop improvement schemes which are linked increasingly into the emerging system of agricultural universities designed to serve India on a national scale.

These institution building operations are long term in implementation, but it is essential that in the short term the food deficit nations, and the cooperating agencies, make commitments to these program goals and assign financial and human resources to get such ventures started.

Building indigenous institutions and systems for adaptive research is only one aspect of the establishment of self-help capability in food deficit nations. Guidelines to assist in analyses of limitations in the broader spectrum of agricultural development have been formulated by A.I.D., with special consideration to the following components:

"A. General Government Policies and Services

1. National allocative and budgetary decisions, involving both foreign exchange and local currencies for investment in agriculture.

2. General economic policies such as import, investment, exchange, etc., as they may affect agricultural investment and growth.

3. Price policies that will ensure a viable and productive relationship between the prices farmers receive for their produce and those they pay for needed production inputs.

4. Policies for equitable credit and land tenure arrangements.

5. A capacity for analysis and for strategy and policy planning.

"B. New Technology, Including Research, Extension and Education

1. The effective introduction of improved breeds and strains of livestock; plant seeds and materials; and the production practices.

2. Adaptive research to ensure the compatability of new varieties and production practices to the variable soil and climatic conditions with special attention to the hazards of destructive diseases.

3. Effective systems of research, education, and extension to ensure the constant production of innovations necessary for continuous growth in agricultural production.

"C. Physical Inputs for Production

1. Importation or manufacture of fertilizers, pesticides and improved tools and machines.

2. Marketing and distribution of production inputs with attention to price as well as to availability.

"D. Markets and Related Services

1. Determination of existing and potential market demands including domestic and foreign outlets.

2. The adequacy and efficiency of transportation, storage, and processing organizations and facilities.

"E. Institutions

1. The institutional base for national programs of research, education and extension.

2. Self-help mechanisms and incentive systems for rural people, such as local self government, cooperatives, rural credit, farmer associations and tenure arrangements.

3. Improved systems of farm organization, operation and management including the comparison of costs, benefits and profitability of (a) production alternatives and (b) changes in farm organization, production systems and selection of crop and livestock enterprises.

"F. General Infrastructure

1. Transport, power and related services and structures supporting agricultural operations.

2. Health levels and services necessary for individual productivity in agriculture.

3. Industrial investment and services directly linked to food production and distribution.

4. General education which undergirds specific education

The need to increase the U. S. capability to carry out a more effective foreign aid program is recognized by Senator George McGovern of South Dakota, who introduced the Bill S 1212 in 1965, to provide federal funds for strengthening U. S. institutions. Although S 1212 was not acted upon by the Congress last year, the basic philosophy and intent of that Bill is incorporated in the amendment under Section 211(d) of the Foreign Assistance Act of 1966 which provides:

> "Not to exceed $10 million of funds made available under Section 211, or under Section 252 (other than loan funds), may be used for assistance, on such terms and conditions as the President may specify, to research and educational institutions in the United States for the purpose of strengthening their capacity to develop and carry out programs concerned with the economic and social development of less developed countries."

It should be noted that the grant authority relates to improvement of the capability of U. S. institutions <u>to carry out the objectives of the foreign aid program.</u> This mission-oriented feature is not included in the similar grant authority for the International Education Act which is broadly designed to improve mutual understandings in foreign contacts and relations.

Commitments will be required on the part of the grant receiving institutions, through changes in institutional organization, in curricula, and in library resources, and by staff members to pursue careers in the international field.

It is recognized that if universities are to make such commitments, they will require evidence of long term support to guard against policy changes and variations in A.I.D. budgets. It is expected

that the funds under Section 211(d) will be furnished under grants rather than contracts, to insure reasonable flexibility for the universities in building the types of resources and capabilities required. An advisory committee will be established to insure attention to top priority program needs and to guide the selection of grant recipients.

One of the top priority areas for support is agricultural development in India, particularly to increase food grain production in that country. A.I.D. staff members are working with the representatives of the U. S. Land-Grant Universities of Illinois, Missouri, Tennessee, Ohio State, and Kansas State, that have formed a "Council of U. S. Universities for Rural Development in India" to develop an effective grant program.

Although some of the added U. S. institutional strength will be directed toward specific country programs or geographic areas, support will be given also to centers of competence in selected problem areas such as land tenure, credit institutions, irrigation agriculture, and similar fields.

Basic Decisions in the Short Run

The U. S. Government has been involved in some type of cooperative effort to improve conditions in less advantaged nations for almost a quarter of a century, dating back to March of 1942, when the Institute of Latin American Affairs was established to help our Latin American neighbors with the development of their resources. Yet there persists a concept that the foreign aid effort is temporary.

The lack of certainty about U.S. intentions and degree of commitment has been an important factor in the failure of the U.S. foreign aid program to make more meaningful progress in the development of agriculture, where growth objectives require long range planning, sustained support, and capable leadership from professional personnel who are committed to this effort as their first priority career objective.

Another deficiency of our past aid programs that relates directly to the critical and growing world food deficit is the reluctance to engage firmly the factors curtailing production of food grains and other commodities abroad during the time such commodities were in surplus in the United States. The ten years that were lost while we pursued this restricted program will be fully reflected in the events of the ten years ahead.

The principal question is whether decisions with respect to support for the foreign aid program will be sufficiently distinct in the future to encourage a full fledged "War on Hunger" or whether support for technical programs, including research and education, will be at such uncertain and fluctuating levels as to permit only skirmishes at the fringes of the battlefield.

The Foreign Assistance Act of 1966 included a number of progressive provisions, such as the Mondale Amendment, directing more attention to adaptive research to increase production of food grains in the developing countries, and the Section 211(d) providing new grant authority to strengthen U. S. capability to carry out a more meaningful foreign aid program. The significance of these amendments is blurred, however, by the decisions of the Congress to reduce the central research budget of A.I.D. from an already modest ceiling of $12 million to a ceiling of $10 million, and to reduce the technical assistance budget from $231 million to $200 million, thereby curtailing the capability of the Administration to follow-up and implement the provisions of these amendments.

There is need for comparative assessment of various international or non-domestic programs that are judged to be in our national interest. There is rather general acceptance of an annual national budget of more than $50 billion for defense and of the level of military spending which had accelerated last month to a rate of $63 billion annually. We accept annual budgets of $5.0 billion to project hardware into the atmosphere with great precision, to seek new areas to explore. Yet there is widespread uncertainty and concern about an annual investment of less than $3 billion for the War on Hunger, and the related international cooperation to improve the education, health, and general well-being of people in cooperating friendly nations. It may not be necessary to equate fully the levels of living on a world-wide basis but a spread of per capita income

from the $2,700 in the U. S. to the less than $100 in many developing nations represents a sizeable opportunity gap.

We cannot judge precisely the size of the investment we might best make in the peaceful international collaboration in economic and social development. If, however, we accept the expenditures of more than $50 billion annually for planes, guns, and bullets for the intangibles of national and international defense, it would seem that a U. S. investment of less than seven percent of that amount for improving the nutrition, health, and general conditions of living is rather modest. It would seem wise to alleviate stresses of living in the disadvantaged nations if by so doing we can reduce the costs for containing such stresses by military force.

The prime short run decision, therefore, is whether we are prepared as a nation for the application of financial and human resources to the level of sustained effort that will be required if we are to give meaning to the pronouncement of President Johnson, "that the United States lead the world in a war against hunger."

References

1. "Changes in Agriculture in 26 Developing Nations, 1948 to 1963." Economic Research Service, FAER 27, U. S. Department of Agriculture, November, 1965.

2. "Estimated World Fertilizer Production Capacity as Related to Future Needs." Tennessee Valley Authority, Muscle Shoals, Alabama. February, 1966.

3. Ewell, Raymond. "Population Growth and Birth Control." Journal of International Health, Volume 2. No. 1. Fall, 1966.

4. Huffman, Donald C. "Proceedings of the Southwestern Conference on The World Population Explosion and Its Implications for Agriculture and the South." Louisiana State University, Baton Rouge, Louisiana. April, 1966.

5. "Military Spending Increases to $63 Billion Annual Rate." The Evening Star. Washington, D. C., October 21, 1966.

6. Narvaez, Ignacio, and Qureshi, S. A. Annual Technical Report, Accelerated Wheat Improvement Program, West Pakistan, Lyallpur Agriculture Department, Government of West Pakistan, Lahore August, 1966.

7. Schultz, T. W. "Food for the World: Policy Choices" Statement to the Committee on Agriculture of the House of Representatives, Washington, D. C., February 18, 1966.

8. West, Quentin M. "World Food Needs." Economic Research Service, U. S. Department of Agriculture. February, 1966.

World Food Production Prospects and Potentials

The opportunity to participate in this program has special significance to those of us who share the task of shaping our foreign aid program. The initiative taken by Dean E. V. Smith and his colleagues, together with the staff of the North Carolina Agricultural Policy Institute, reflects the growing recognition by leaders in American agricultural research and education that responsibility for the U.S. role in the worldwide "War on Hunger" resides not just with those few people in Washington who are associated with the Agency for International Development.

It is particularly helpful to appear on this program after the excellent summary of the world food situation by Dr. Quentin West. At other meetings in recent months, I have cited information from his report of last February on "World Food Needs" so regularly that I have been identified on a few occasions as the progenitor of these statistics. No such plagiarism has been intended.

There is, and will continue to be over the next few years, considerable divergence of opinion about the seriousness of the world food problem. Perhaps the most persistent warning that the increase in world population represents "a road to disaster and a threat to world peace" is sounded by Dr. Raymond Ewell, Vice President for Research of the State University of New York at Buffalo. Dr. Ewell points out that during

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, at the Regional Conference on the World Food Situation - Implications for Southern Agriculture, Sponsored by the North Carolina Agricultural Policy Institute and Auburn University Agricultural Experiment Station, Auburn, Alabama

December 16, 1966

the past five years food production has increased at the rate of 1.5 percent per year, with a worldwide population growth of over 2 percent per year. Dr. Ewell suggests that if present trends continue "it seems likely that famine will reach serious proportions in the more vulnerable countries, such as India, Pakistan and Communist China, in the early 1970s. Indonesia, Iran, Egypt, Turkey, Brazil, Peru and some other countries would follow within a few years. And most of the countries of Asia, Africa and Latin America would fall in the same category by 1980." Dr. Ewell predicts that such a famine would be of massive proportions, affecting hundreds of millions, possibly even billions, of persons and that "If this happens, as now appears probable, it would be the most colossal catastrophe in history".

There are, of course, many who adopt a more moderate view, ranging to those who feel that the world will continue to feed itself because it always has done so and the collective ingenuity of men around the world will enable them to keep abreast of their requirements.

Regardless of the exact degree of crisis that may confront us in the decades ahead, it seems apparent that natural events will not provide the solutions and special steps must be taken. We are, after all, concerned not with a bare bones type of subsistence but with improvement in levels of living, with better diets, better health services, and higher levels of literacy.

As we chart the course ahead to meet rapidly increasing world food needs we might consider (1) the immediate or short-term requirements,

to be met largely from the food grain surplus producing nations, (2) the intermediate period, with needs to be met primarily through adaptation of technology from advanced nations, and (3) the longer term requirements, to be met through indigenous "self-help" capability.

Meeting Short-Term or Immediate Needs

The PL 480 program has been redirected, through the Food for Peace Act of 1966, to the concept of producing for world needs. This presents new challenges to U.S. agriculture.

Dr. Fred H. Wiegmann of Louisiana State University, in discussing economic implications for Southern agriculture in the world war on hunger, at the Conference at Baton Rouge last April, suggested that rice production could be expanded rapidly in the South and might compete favorably with cotton in the Delta areas and in some other regions. He pointed out also that the Southern States grow about 19 percent of the total U.S. output of wheat, a crop that is becoming increasingly attractive to farmers in Mississippi, Arkansas, and Louisiana, with many farmers double-cropping wheat with soybeans.

Farming adjustments in Southern agriculture will require continuing guidance from those familiar with the potentials for shifting cropping patterns in this region. A lead, however, is furnished by Dr. Wiegmann who suggests, "Cotton is still the most profitable crop per acre and per dollar invested, over most of the South. However, with continuing changes in institutions, economic conditions, and technology, and with an increasing emphasis on food production generally, food and feed production could well assume an increasing relative importance in the South."

The expanded production of other nations must be taken into account as we adjust domestic production gradually over the next several years to meet worldwide needs. Bumper crops were harvested in Canada, Australia, and the U.S.S.R. in 1966. Canada's national economy is, of course, heavily dependent upon its international wheat market. With expansion from these countries, as well as from some Latin American countries where production may be exploited, it will be necessary to schedule U. S. production increases carefully to avert excessive short-term surpluses and lower world prices.

A factor still to be evaluated is the effect of new technology in increasing production in the developed countries. The yields per acre of rice in the Southern U. S. have more than doubled in the past 20 years, from 18.6 bushels per acre in 1946 to 41.8 bushels in 1965. Prospects for increased wheat production are indicated from recent experience in wheat breeding and agronomic research in the Pacific Northwest. A rather astonishing performance has been achieved with the short strawed "Gaines" variety which was selected from hybrids involving the "Norin" wheats introduced from Japan following World War II. By adjustments in soil fertility and water management, yields under field conditions with the Gaines variety have increased steadily from 133 bushels per acre in 1962, to 167 bushels in 1963, 190 bushels in 1964, 209 bushels in 1965, and 216 bushels in 1966.

The technological feasibility for producing substantially higher yields of wheat, rice, corn, sorghums, and millets has been demonstrated

in the advanced nations but economic limitations to such maximized production must still be assessed. We are aware also of the economic and social limitations confronting food deficit nations with respect to continued food grain purchases,where repayment burdens from dollar sales, or large accumulations of local currencies by the advanced nations, will create and increase tensions with nations struggling for economic and political freedoms.

The Intermediate Term - The Next Decade

Production per acre can be increased rapidly and substantially in many of the developing nations where yields of the major food grains are only 25 to 50 percent of the yields in the U. S. or in other agriculturally advanced countries. The increased use of fertilizers, pesticides, and herbicides will be essential in expanding food production during the next few decades. The Agency for International Development supported the study by the Tennessee Valley Authority that was published in February of this year, on plans for world fertilizer production capacity as related to future needs. A.I.D. expects to continue to work closely with the TVA to maintain up-to-date assessments of the world fertilizer supply and demand situation.

The A.I.D. supported project conducted by North Carolina State University on soil testing in Latin America will be most helpful in guiding the effective use of additional fertilizer inputs in this hemisphere.

A major impact can be achieved in food deficit nations in the next decade by the introduction of improved high-yielding varieties of the major food grain crops, particularly wheat and rice, and of modern methods for their

production. Evidence of what can be accomplished is furnished by the experience in Mexico, where wheat yields per acre were increased from 11 bushels in 1943 to 39 bushels in recent years. The potentials for increasing rice production are evident from the research of the International Rice Research Institute at Los Banos, the Philippines, where yields exceeding 9 metric tons per hectare were obtained in 4 separate experiments during the 1965-66 dry season, with one experimental test yielding over 10 tons. These plantings were made between mid-November and early January, and harvested from mid-March to mid-May.

The high yielding dwarf wheats developed in the cooperative program of the Rockefeller Foundation and the Government of Mexico, commonly referred to as the "Mexican wheats", are being utilized by the Government of India as a major input for achieving increased production in the next few years. These varieties grow to about 30 to 40 inches in height, have stiff straw, and can convert large quantities of nitrogen and other plant nutrients into high yields without lodging. The purchase of 18,000 tons of seed of the Mexican wheats in August of 1966 by the Government of India from the Government of Mexico represents the largest international shipment of a seed stock of a major food grain in history. This seed, together with the seed produced in India this year will enable India to plant approximately one million acres to the Mexican varieties in 1966-67.

The Government of Pakistan also is depending heavily upon the high-yield capability of the Mexican wheats and has set a goal of achieving self-sufficiency in wheat production by 1970. In a project supported jointly

by the Ford Foundation, the West Pakistan Government in June 1965 imported 350 tons of seed of the Mexican dwarf wheats Penjamo 62 and Lerma Rojo 64. There will be about 500,000 acres planted next year to these varieties.

Other countries that are faced with food grain deficits, including Turkey, Afghanistan, Nepal, Jordan, Morocco, Tunisia, and Korea, have expressed interest in improvement of their wheat production through the adaptation and use of the high yielding wheats developed through the cooperation of the Rockefeller Foundation and the Ministries of Agriculture in Mexico, Colombia, and Chile during the past 20 years.

The highly productive rice varieties that have been identified or developed by the International Rice Research Institute are moving into production in a number of countries in the rice bowl. A cooperative project to accelerate improved rice production was undertaken in February, 1966 between the Institute and the Government of East Pakistan, with support from the Ford Foundation.

An All India Rice Improvement Scheme was initiated under the leadership of the Indian Council of Agricultural Research in November, 1965, developed largely around the Taiwan variety, Taichung Native 1, which was found to be outstanding in yield in tests conducted in a number of rice bowl countries by the IRRI. It is expected that there will be about 1.2 million acres planted to this variety and about 1.0 million acres planted to the new variety developed by the Institute, IR8-288-3, in the next season (Kharif) in India. Arrangements are being completed for A.I.D. support to the International Rice Research Institute to strengthen its collaboration in India.

Similar intensive rice production improvement programs are under way in the Philippines and in Thailand. These activities should be expanded through increased support by A.I.D., the U. S. universities cooperating in that Region, and other organizations, to build on the programs established primarily through the initiative of the Ford and Rockefeller Foundation.

The Long Term - Building Indigenous "Self-Help" Capability

As we look ahead to the most essential and critical task, the building of self-help capability, it seems worthwhile first to assess our experience during the 16 years of collaboration in international agriculture following the passage of the Act for International Development, Public Law 535, authorizing the Point IV programs on June 5, 1950. We did not realize at that time the many "unknowns" we would encounter in upgrading levels of living in nations that have been classed as "poor, tropical, and agricultural".

As we reflect on the experience of the past 16 years, it is evident that excessive emphasis was placed on meeting immediate needs and too little effort on building for the future. We gave inadequate attention to the establishment of indigenous agricultural research and education institutions to furnish the sustained flow of new materials and knowledge to perpetuate growth.

Dr. T. W. Schultz, Professor of Economics of the University of Chicago, pointed out in 1963, "Although our Government has been actively engaged in technical assistance in agriculture throughout Latin America for two decades, the sad truth is that not a single first class agricultural

research center has been developed as a consequence of these activities." Dr. Schultz recognized the advances in agricultural development in Mexico and elsewhere in Latin America, as well as in India, but pointed out that progress in the establishment of a research base was "not because of any technical assistance from the U. S. Government" but primarily through efforts of private foundations.

A number of factors have combined to defer or detract from the building of indigenous agricultural science and technology. A review of some of these might be worthwhile, to form a basis for guiding future programs.

"The Extension Bias"

The initial efforts of our Point IV programs emphasized "the transfer of U. S. know-how", on the assumption that the reservoir of science and technology from the U. S. could improve traditional agriculture. We learned from experience in cooperation overseas that many of the materials and techniques from the temperate zone can not be adopted directly in the tropics.

We have assessed incorrectly, also, the stock of agricultural science and technology available in the developing countries. This was reflected in the judgment of the first Point IV team of three specialists from the U. S. Department of Agriculture, following their ninety day trip through twelve Eastern Hemisphere countries to discuss with foreign government leaders cooperative projects that might be undertaken under the

anticipated Point IV program. The recommendations of this team, following their return to the U. S. on April 27, 1950, included "cooperation with Iran in development of agricultural extension and research, cooperation with Ceylon in an agricultural extension program to increase the efficiency of rice production, and cooperation with Pakistan in improving agricultural extension work".

The tendency to over-estimate the science and technology resources in South Asia as they bear on agricultural development has been pointed out by Dr. John Mellor of Cornell University as characteristic of foreign technicians (U.S. specialists) who visit these countries for short periods of time, or who work primarily in consulting roles. This error in judgment is frequently made also by non-scientists, as in the case of the foreign aid officer in a Far East country who stated that there was no need for additional agricultural research support in the country in which he was located because "there is a reservoir of knowledge sufficient for the next 25 years". This reflects a substantial lack of understanding of the biological forces in agriculture that require a constant flow of solutions for a constant series of new problems.

The expanded programs for introduction of the Mexican wheats and the Taiwan rice varieties by the Governments of India and Pakistan indicate the growing appreciation, in the past two or three years, of the importance of new technology in agricultural development. This is recognized also by an increasing number of agricultural leaders in the United States and in the

amendment to the Foreign Assistance Act of 1966, included as Section 211(e), which states:

> "In any developing countries or areas where food production is not increasing enough to meet the demands of an expanding population, or diets are seriously deficient, a high priority shall be given to efforts to increase agricultural production, particularly the establishment or expansion of adaptive agricultural research programs designed to increase acre-yields of the major food crops.
>
> "Such research programs, to the greatest extent possible, should be based on cooperative undertakings between universities and research institutions in the developing countries and United States universities and research institutions".

This amendment is a precise invitation, and challenge, to the State Agricultural Experiment Stations.

Agricultural Development Versus Industrialization

Much has been said about the relative significance of agriculture and industry in the development process. They are, of course, interdependent and both are important.

A number of countries, failing to recognize the need for a solid agricultural base for economic development have shifted, prematurely, their major financial and human resources to industrial development activities. This is apparent in the case of India where in spite of the special efforts required to avert famine conditions in 1950 through a

"Grow More Food Campaign", the Government of India decided in 1955 that the food problem had been solved. So major emphasis was placed on industrial development in the second five year plan.

The present inadequacy of Indian agriculture is evident in the need of that nation to import approximately nine million tons of food grains during the past year, and the expectation that such import requirements will not diminish significantly in the years immediately ahead. The draft outline of India's fourth five-year plan provides that agriculture, population control, and supporting industries are to receive top priority through the period ending in March 1971. The urgency for agricultural development in 1966 is enhanced by the diminished attention given to this sector in 1956, and throughout the past decade.

The Effect of U. S. Crop Surpluses

In his Point IV message on January 20, 1949, President Truman stated, "Our aim should be to help the free peoples of the world, through their own efforts, to produce more food, more clothing, more materials for housing, and more mechanical power to lighten their burdens."

The increasing concern in the U. S. about the build-up of agricultural commodities, including wheat and rice, following the Korean War (and following the Point IV message) caused the diversion of attention from the directive "to produce more food" in our foreign cooperative programs. This has been particularly true with respect to programs of research to increase production of wheat, rice and other commodities in surplus in the U. S.

The tendency to restrict attention to efforts abroad that might have a deleterious effect on our domestic economy is normal and natural. But our policies must be reassessed at new levels of sophistication as we shift emphasis toward more rapid agricultural development in our future foreign aid programs.

It is increasingly apparent that we cannot hope for a peaceful and orderly world if half of its people suffer, constantly, the pangs of hunger and ravages of disease encouraged by malnutrition. Improved communication increases awareness around the world that hunger is not universal and need not necessarily be accepted. Food riots or civil disorders may not be directed specifically against those of us with more than adequate diets, but as they result in the overthrow of friendly local governments we are caught up in the outwash of the unstable and perhaps even hostile political systems that result.

In addition to the moral issues in equalizing opportunities for more adequate nutrition, health, and literacy, and the contribution to world peace and stability, we should reassess the mutual economic benefit from expanded cooperation in agriculture. The prosperity of American agriculture depends upon a high level of commercial export business, and the ability of other nations to purchase food and agricultural products from us depends upon their general economic development. In spite of the fact that it is the poor countries which are hungry, it is the rich countries to whom we sell our food.

Our 1966-67 agricultural export sales totalled about $7 billion, including hard cash sales of $5.4 billion. They are expected to rise to $8 billion by 1970 and to $10 billion by about 1980.

Evidence of the returns to American agriculture from foreign aid investments is furnished through the results of our cooperation with Japan, Israel, Spain, and Taiwan. All of these countries are now on their own and receive no financial aid from the United States. All of them have achieved, for the past decade or more, agricultural growth rates substantially above our own. They range from the 2.7 percent average annual growth in agri-

its enormous indigenous farm production growth, still increased its imports of our farm products by 305 percent. Spain increased its imports by 615 percent, reaching a total of $148.5 million last year. And Japan increased her imports of American farm products by 182 percent -- to a total of $865.5 million -- to become, by a wide margin, our best customer. This has happened in just five years and suggests the potentials for American agriculture if we strengthen our programs to assist developing countries to achieve similar capacities to buy our farm products.

The Congress has emphasized the importance of the development of self-help capability in the ~~Missions~~ nations that now have, or that are confronted with, food deficits. This is clearly defined in the Food for Peace Act of 1966 and in the Foreign Assistance Act of 1966.

President Johnson, in his message to Congress on Foreign Aid on February 1, 1966 stated, "We cannot meet the world food needs of the future, however willing we are to share our abundance. Nor would it serve the common interest if we could.

"The solution is clear: an all out effort to enable the developing countries to supply their own food needs through their own production or through improved capacity to buy in the world market."

Developing New Strategies for International Agricultural Development

It is not possible to chart precise courses for improvement of agriculture in the many developing nations with their varied economic, political, and social environments. It is essential, however, to evaluate the strengths and weaknesses in the agricultural sector and to focus more sharply the resources of the donor and recipient nations on the deficient components.

We are developing more specific guidelines to determine whether the countries themselves are doing everything that can be reasonably expected of them in improving their agricultural economy. We plan to conduct field reviews, in which U. S. specialists will join with local agricultural leaders, to evaluate the adequacy of efforts of the developing nations with respect to their agricultural budget provisions, their policies to stimulate private sector activities required by agriculture, their provision for new technology through effective agricultural research and education programs, their arrangements for effective marketing, and other factors. We would expect such reviews to furnish a base for more effective long range planning and for continuing assessment of the direction or redirection of cooperative efforts.

Coordination of Effort

We are fully alert to the joint responsibilities of the U.S.D.A. and A.I.D. in carrying out certain provisions of the Food for Peace Act of 1966. Secretary Freeman has personally reviewed the agricultural situation in a number of countries, including India, Pakistan, and Brazil, during the past year. A.I.D. Administrator Gaud has expressed his strong conviction "that the number one problem in the aid business is whether the world will be able to feed itself in the next 15 to 20 years, whether we will be able to achieve a balance between food and mouths." There is a strong mutual desire on the part of these two leaders to move forward vigorously and to work in harmony in the War on Hunger.

Proposals have emerged recently, and will probably continue to come forth, that the foreign aid program should again be reorganized. As we look at the many shifts in organization and program emphasis over the past 16 years,

it should be apparent that what we need in the foreign aid program is a higher degree of stability and not a perpetual dissipation of effort in reorganizing and re-establishing lines of communication.

We are aware of the continuing need to improve relations between A.I.D. and the various non-government organizations. The Agency has made considerable progress in improving communications in recent years, with the establishment of the Advisory Committee on University Relations and on Health Manpower, and through the continuing efforts of the Research Advisory Committee. Close working relations are maintained with the International Rural Development Office, under the directorship of Dr. Louis B. Howard, which serves as the linkage between A.I.D. and the National Association of State Universities and Land Grant Colleges.

Building "Long-Range" Capabilities

The institutions for agricultural and rural development in the United States evolved from their establishment under the Morrill Act of 1862, through the addition of the experiment station component under the provisions of the Hatch Act of 1887, and the addition of the extension programs through the Smith-Lever Act of 1914. We must telescope time since no developing nation can devote a century to the establishment of similar research and education centers. We recognize, however, that the 10 to 15 years that have been devoted to such projects may be closer to the half way mark than to the finish line and a continuing concentrated effort may well be needed.

The building of institutional capability in the developing nations, for sustained inputs of science and technology for agricultural self-sufficiency and growth, cannot be achieved by the casual or intermittent attention that has characterized many of our efforts in past years.

The value of sustained support and guidance is fully evident from the Rockefeller Foundation Agricultural program that was initiated in Mexico in 1943, had the benefit of leadership from Dr. J. G. Harrar (now the President of the Rockefeller Foundation) for a period of nine years, and from a number of staff members who have remained with that program for more than twenty years. The Foundation's agricultural program in Colombia has had only two leaders over its 16 year span, and the program in India has had the steady guidance, for 9 years, of Dr. Ralph W. Cummings who is known to many of you through contacts during his years as Director of the North Carolina Experiment Station.

As pointed out by Dr. F. F. Hill of the Ford Foundation, no land grant institution in a wheat growing state in this country would think of undertaking a wheat improvement program with a staff consisting wholly or in large part of persons on two year assignments from the Rothamstead Experiment Station (in England). It simply would not work, and we know it, Neither are short term consultants, no matter how knowledgeable or distinguished, a substitute for qualified professionals who stay on the job year in and year out.

Dr. Norman E. Borlaug of the Rockefeller Foundation, who directed the wheat improvement program in Mexico which furnished the striking increase in wheat production in that country, and who developed the "Mexican wheats" for use in Pakistan and India, suggests that a new look at technical assistance personnel is in order. Dr. Borlaug suggests:

> "The main bottleneck to expanding and increasing the efficiency of assistance programs in developing countries is the shortage of the right kind of U.S. scientists. To be highly effective we must find more scientists--who have a flare for adaptation

of research to local production problems. They must be "doers" and not just "theorists" and we are not developing this kind of scientist in our U.S. educational institutions in adequate numbers. Moreover, they must be scientists who can function effectively in provoking change in a foreign environment, again something that is lacking in many of our best scientists when they leave home. They above all must be enthusiastic and capable of capturing the imagination of government officials, scientists and farmers of the host country and get programs rolling."

"I am sure that we must have more scientists with these characteristics than we are identifying and sending to foreign assignments. I am also convinced that most U.S. universities that have Foreign Assistance Contracts assign their staff members to these projects believing that if a Professor is highly effective in a U.S. university he automatically will

New authorization for A.I.D. to increase U.S. institutional capability to carry out a more effective foreign aid program is furnished in the amendment under Section 211(d) of the Foreign Assistance Act of 1966 which provides:

> "Not to exceed $10 million of funds made available under Section 211, or under Section 252 (other than loan funds), may be used for assistance, on such terms and conditions as the President may specify, to research and educational institutions in the United States for the purpose of strengthening their capacity to develop and carry out programs concerned with the economic and social development of less developed countries."

The reduction in funds for technical cooperation in the Agency's FY 1967 budget precludes the effective implementation of this program this year. We are moving ahead, however, with discussions with a number of U.S. land grant institutions to develop plans for activating this authority in FY 1968.

Institutional Patterns

Further attention should be given to the resource bases for the development and transfer of new technology. Considerable information and materials can be supplied from the U.S., if proper attention is given to adapting such innovations to fit them to specific local environments.

The International Rice Research Institute has been described as the outstanding center for rice research in the world, and this institution should serve most effectively as the source of new materials and knowledge for application to rice improvement in the rice bowl countries. The experience in Pakistan and in India will be most helpful in determining how to link the capability of the IRRI into specific national programs.

Similar centers for research on other problems of tropical agriculture should be considered. It is important, however, that we determine the precise job to be done, or the expertise to be developed, as these centers or institutes are conceived and established.

It is recognized that no nation can or should borrow agricultural science and technology on a continuing basis. As Dr. Hill has pointed out, U.S. agricultural development would not have been served well from the Rothamstead experiment station in England. Similarly, U.S. agricultural development would not have been served effectively by only one major center of agricultural research capability such as the Beltsville Research Center. Indigenous national systems of research and education are as necessary to the developing nations as they are to advanced agricultural countries.

"Maintaining" Productive Capability

Administrative and political leaders of both donor and recipient nations concerned with agricultural improvement must be made aware that biological forces are dynamic and there is need, therefore, to protect and maintain new productive capacity. As pointed out by Dr. Eugene B. Hayden of the Crop Quality Council in his testimony before the National Advisory Commission on Food and Fiber on September 15, 1966:

> "The reduction in U.S. winter wheat production prospects by more than 130,000,000 bushels in two months this spring, as a result of extensive drought and frost injury, emphasized to many that we are dealing with complex biological systems which are always vulnerable to weather, as well as to attacks by plant diseases and insect pests."
>
> "No one should be complacent, as crop producers, grain firms, railroads, implement manufacturers, millers and macaroni manufacturers can well remember the disastrous stem rust epidemics which destroyed up to 2/3 of the Upper Midwest wheat crop for several years in a row in the early 1950's."

The explosive forces of disease and insect outbreaks are not peculiar to U.S. conditions and will be even more hazardous in developing nations as they introduce new crop varieties and increase levels of fertilizer applications. The current heavy reliance on western science and technology may well yield disappointing and even disastrous results if we do not move promptly to establish the indigenous research capability to detect and stay ahead of the series of hazards that we know from our domestic experience are going to appear.

In conclusion, I suggest that the time has come for us to draw more heavily on the experience of the U.S. Department of Agriculture and

the State Agricultural Experiment Stations in the worldwide "War on Hunger." We have gained valuable insights from our foreign cooperation of the past 16 years that should enable us to direct our energies and resources more effectively in the future.

A principal requirement for a more productive effort is a firm commitment on the part of the U.S. public, and by the Congress, to the type of long-term concerted program that is essential for progress in meeting world food requirements.

A high level of statesmanship will be required at local, state, and national levels to keep in sharp focus our efforts to assist nations now politically free, to achieve freedom from hunger and to improve their levels of living -- as distinguished from the struggles in which we are assisting nations to achieve their political freedom and stability. No administrator of A.I.D., no matter how able, can plan or conduct an effective foreign aid program so long as these issues remain confused.

We know from experience that the land grant universities can furnish a high level of program stability, and I hope they will be willing and able to contribute to a higher level of professionalism in our foreign agricultural development activities.

There is a new sense of concern and dedication on the part of the Land Grant system to international education and research. This is reflected in the statements of the Agricultural Division and of the International Affairs Committee in the form of resolutions emerging from the 80th annual convention of the NASULGC last month. As stated by Dr. Louis B. Howard, Director of the International Rural Development Office:

> "There appears to be developing not just a feeling of responsibility but an enthusiasm for a significant place in our university community for international activities. At least twenty land grant universities have formally established the position of Director of International Programs in Agriculture, the resident instruction and the extension committees on organization and policy have appointed subcommittees to investigate their potential roles in international programs, and the experiment station section has been devoting considerable thought to research on international problems."

Our experience in federal-state cooperation in agricultural development has demonstrated during the past half century the rapid progress that can be made through such collaboration. We have a new challenge for agricultural development which should be met through a similar alignment of our federal and state resources, in a fully cooperative effort to wage a war on hunger around the globe.

References

1. Borlaug, Norman E. Personal Correspondence. September 20, 1966.

2. Boulware, James H. "India's Fourth Five Year Plan Focuses on Agriculture". Foreign Agriculture. U.S.D.A., Foreign Agricultural Service. October 3, 1966.

3. Drosdoff, Matthew. "A Century of Technical Assistance to Other Nations". International Agricultural Development Service. U.S.D.A. November, 1966.

4. "Estimated World Fertilizer Production Capacity as Related to Future Needs". Tennessee Valley Authority, Muscle Shoals, Alabama. February, 1966.

5. Ewell, Raymond. "Population Growth and Birth Control". Journal of International Health, Volume 2, No. 1. Fall, 1966.

6. Ewell, Raymond. "Population Outlook in Developing Countries". Dinner Address - Annual Meeting of the Agricultural Research Institute, National Academy of Sciences - National Research Council. Washington, D. C. October 10, 1966.

7. Hayden, Eugene B. Statement to the National Advisory Commission on Food and Fiber. September 15, 1966.

8. Hill, F. F. "U.S. Land Grant Colleges and the World Food Crisis: A Suggested Program of Action". Annual Meeting of the Land Grant College Association. Washington, D. C. November 15, 1966.

9. Howard, Louis B. International Letter No. 18. International Rural Development Office. Washington, D. C. November 30, 1966.

10. Mellor, John W. "Science and Technology in Agricultural Development". Conference on Science and Society in South Asia, Rockefeller University. New York, N. Y. May 2-4, 1966.

11. Narvaez, Ignacio, and Qureshi, S. A. Annual Technical Report, Accelerated Wheat Improvement Program, West Pakistan, 1965-66. Agriculture Department, Government of West Pakistan, Lahore. August, 1966.

12. Ruttan, Vernon W. "Are Grain Surpluses a Thing of the Past?" Annual Meeting, Minnesota Plant Food Association. Minneapolis, Minn. November 29-30, 1966.

13. Schultz, T. W. "Economic Growth from Traditional Agriculture". Agricultural Sciences for the Developing Nations, Cleveland, Ohio. December, 1963. Publication No. 76. AAAS. Washington, D. C. 1964.

References

14. West, Quentin M. "World Food Needs". Economic Research Service. U. S. Department of Agriculture. February, 1966.

15. Wiegmann, Fred H. "Economic Implications for Southern Agriculture in the World War on Hunger". Proceedings of the Southwestern Conference on the World Population Explosion and Its Implications for Agriculture and the South. Louisiana State University, Baton Rouge, La. April 26-28, 1966.

16. The IRRI Reporter. The International Rice Research Institute. Manila Hotel, Manila, The Philippines. Volume 2, Number 4. July, 1966.

American Aid Programs and World Food

In his State of the Union Message on January 10, President Johnson said,

> "Next to the pursuit of peace, the really greatest challenge to the human family is the race between food supply and population increase. That race tonight is being lost.
>
> "The time for rhetoric has clearly passed. The time for concerted action is here and we must get on with the job.
>
> "We believe three principles must prevail if our policy is to succeed.
>
> "First, the developing nations must give highest priority to food production, including the use of technology and the capital of private enterprise.
>
> "Second, nations with food deficits must put more of their resources into voluntary family planning programs.
>
> "Third, the developed nations must all assist other nations to avoid starvation in the short run and to move rapidly towards the ability to feed themselves.
>
> "Every member of the world community now bears a direct responsibility to help bring our most basic human account into balance."

The world food situation has been evolving since World War II as population growth and stagnated yields of food grains in many areas of the world have shifted many developing nations from food grain exporters to importers. The drought conditions in India in 1965, with widespread starvation staved off primarily through the shipment of 8.3

Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Agency for International Development, Department of State, before the 19th Annual Midwest Fertilizer Conference, Chicago, Illinois

February 16, 1967

million tons of food grains from the U. S., dramatized the world food problem and stimulated international awareness of it.

Dr. Raymond Ewell, Vice President for Research at the State University of New York at Buffalo, has been most emphatic in urging vigorous action in both family planning and food production efforts. A more optimistic viewpoint is expressed by Dr. Donald J. Bogue, Director of the Community and Family Study Center of the University of Chicago, who has suggested in the past few months that "The rate of growth will slacken at such a pace that it will be zero or near zero at about the year 2000, so that population growth will not be regarded as a major social problem except in isolated and small, 'retarded' areas."

The rate of progress in establishing effective family planning programs in nations with present or impending food deficits does not stimulate premature optimism. Population specialists in India estimate that nation's 505 million people are increasing at a rate of about 2.9 to 3.0 percent annually, with a net increase of more than 1 million people per month. India faces a food shortage this year of an estimated 10 million tons of food grains valued at about $725 million.

Short Term Prospects for Food Supplies

The Food for Freedom program in the past year has shifted sharply to production for world needs, from the previous emphasis on disposal of U. S. surpluses.

The Economic Research Service of the U.S.D.A. is developing continuous projections of world food supplies and demands. In its report of December 29, 1966 on The Outlook for Grain 1970, the U.S.D.A. predicts that "By 1970 the world supply of wheat will be more than adequate to meet effective demand at prices not far different from present levels". This assumes that the Soviet Union will increase its production and that there will be no major droughts in the large wheat exporting or importing countries.

One reason for optimism is the record world wheat production of 274 million metric tons during the past year which resulted from both increased acreage and higher yields. Fertilizers are, of course, an important factor in boosting per acre yields.

Canada's production of 23 million metric tons in 1966 was 16 percent higher than its previous record in 1963. The wheat acreage in Canada has increased by 1/3 during the past ten years to 12.3 million hectares in 1966 and the use of fertilizer quadrupled from 1957 to 1965.

Australia's wheat area has more than doubled during the past ten years, to 8.3 million hectares, and it is expected that production will reach a record of 11 million metric tons. Applications of superphosphate on wheat lands have levelled off since 1958 and acre yields have not

increased substantially because of the expansion of wheat growing into less favorable production areas.

The Argentine wheat crop of 8.5 million metric tons is the third largest of the past 10 years. The acreage is currently about 20 percent above the average for 1955-59 and further increased production should be possible through the use of fertilizers which is still negligible in the Argentine.

There is a concerted effort under way to enlist more active joint support from developed nations to meet world food requirements. Under Secretary of State Eugene V. Rostow returned recently from a round-the-world trip to urge other nations to assist in meeting India's food needs. U. S. allocations of concessional food grains for India for the remainder of 1967 will be contingent on "appropriate" matching contributions by other countries in food or food related commodities such as fertilizers.

The focus on world food is destined to be cooperative as well as competitive in the future and the effect of adjustments in production in other countries that have surplus grain growing capability on U. S. agriculture must be evaluated constantly. The predictions for U. S. production suggest that exports may rise from the average of 20.6 million metric tons during the past five years, when we were drawing

down our reserve stocks, to about 24 million metric tons in 1970.

Building "self-help" capability in food deficit nations

There is increasing awareness on the part of government leaders and specialists in international agriculture that the world food budget will be balanced only by increasing production in the developing nations. Food aid, whether from the U. S. or from a consortium of developed nations, is only a stop-gap and temporary solution.

President Johnson, in announcing the emergency 2 million ton grain allocation for India on February 2, emphasized that India must eventually meet its own needs because the day is approaching when food shipments from abroad may no longer be possible. The President referred also to "The growing realization in the developing world that long-term economic growth is dependent on growth in agriculture".

Unfortunately, we do not have a ready formula for modernization of agriculture. As Secretary Freeman has stated, "The hungry two-thirds of the world will have to work out their problems of farm production just as we did in the United States. But we had plenty of time in this country; we had good land, good water, a healthy and skilled people.

Over a century we gradually developed our system of roads, factories, processing plants, agricultural colleges, banks, and all the other things required for modern farm production. But the hungry two-thirds of the world must compress their progress into one generation, or less."

It is difficult to identify clearly those factors in the agricultural sector that are of greatest significance in development. We have, however, established guidelines which we are using to assess the agriculture in some of the key countries, with special emphasis on the following components:

A. General government policies and services, including budget allocations to agriculture; capability for program analysis and planning; import-export policies; and decisions with respect to price incentives, land tenure, taxes, and agricultural credit.

B. New technology, including research, extension and education, with special attention to the development and introduction of improved strains or breeds of crops and livestock, and practices for their production; and the establishment of effective systems of research, education and extension to insure the constant flow of innovations for continuous growth in the agricultural sector.

C. Physical inputs for production, including fertilizers, pesticides, and machines, with appropriate attention to their marketing, distribution, and cost, as well as availability.

D. Markets and related services, including domestic and foreign outlets; adequacy of marketing systems, transportation, storage, and the processing organization and facilities.

E. Institutions, for national programs of research, education and extension; local self-government; cooperatives; rural credit; and the farm organizations or associations that are essential to help guide changes in production systems, tenure arrangements, etc.

F. General infrastructure, including transport, power, communications and related services; health services, industrial investments, including private enterprise; and general education to facilitate economic, political and social advance in the rural as well as urban societies.

The above factors are helpful in guiding allocations of the limited technical assistance staff and financial resources of our foreign aid program. We cannot address all of them in the brief time this morning but we can focus on a few of the more significant, and perhaps most seriously neglected, elements of mutual interest.

New Technology

In President Johnson's State of the Union Message, he emphasized the need for attention to "the use of technology and the capital of private enterprise". We have learned from the experience of the past 15 years, since the establishment of the "Point IV" program, that the extension of American know-how to the agricultural conditions of tropical or subtropical regions is largely ineffective. We realize now that American technology cannot be "adopted" but it must be "adapted".

An increasing number of leading U. S. agriculturists with experience in international agricultural development are emphasizing the importance of adaptive research, to breed crop varieties suited to specific soils and climates, to fit fertilizer applications to specific soil fertility and moisture regimes, to improve pest control measures, and to design planting, cultivation and harvesting practices that will insure maximum returns from labor and land resources.

The experience of the cooperative program of the Rockefeller Foundation and the Government of Mexico, initiated in 1943, furnishes excellent evidence of the potentials for improving production of basic food crops through a well planned and sustained program of research and education. Research on wheat breeding and improvement in Mexico has increased national average yields from about 11 bushels in 1943 to more than 39 bushels in recent years.

The Mexican wheat varieties are non-photosensitive and adapted to a wide range of day length conditions so they are suited for growing in environments extending to 40 degrees or more north and south of the equator. They grow to about 30 to 40 inches in height, have stiff straw, and can convert large quantities of nitrogen and other plant nutrients into high yields without lodging.

The "Mexican wheats" have been widely tested in other countries in Latin America, in Asia, and in Africa, and their capacity to produce 3 to 5 times the yields of locally grown varieties in these countries promises to supply the type of breakthrough in international agricultural development that hybrid corn furnished in stimulating recognition of science and technology in agriculture in the United States 35 years ago.

The Government of India purchased 18,000 tons of seed of the Mexican wheats from the Government of Mexico in August 1966. This is

the largest international shipment of seed stock of a major food grain in history and will enable India to plant about one million acres to these varieties in 1966-67. It is estimated that next year India may have 40 to 50 percent of her wheat crop in these varieties.

The Ford Foundation is collaborating with the Government of West Pakistan in expanding production through the use of the high yielding Mexican wheats. The goal of the Government of Pakistan is to achieve self-sufficiency in wheat production by 1970 and the experience of the past two years suggests that this goal may well be achieved.

About 60 tons of seed of the Sonora wheats were planted by more than 100 farmers in the Adana area of Turkey last fall and the Government of Turkey is considering a massive importation of seed of the Mexican wheats from Mexico this year.

We have a similar breakthrough of new technology in rice production that may be equally significant in meeting food requirements in the rice bowl nations of Asia. Rice varieties developed in Taiwan and by the International Rice Research Institute, which was established by the Ford Foundation and Rockefeller Foundation in cooperation with the Government of the Philippines at Los Banos, have demonstrated wide adaptability and high yielding capacity in India, Pakistan, and other countries in the region. Cooperative projects involving the International Rice Research Institute, the Ford Foundation and Government of East Pakistan; and the Government of India, A.I.D., and the Institute, promise to make a substantial

impact on rice production in these two countries over the next several years.

The Mexican wheats and the outstanding new rice varieties are highly productive over a wide range of environments and conditions of soil fertility. They have the capacity to respond with exceptionally high yields when high levels of nitrogen fertilizers are applied. In Pakistan, the local tall wheat varieties respond with increased yields to fertilizer levels of about 60 pounds of nitrogen per acre, when P_2O_5 levels are adequate. The dwarf wheats on the other hand continue to increase in yield at fertilizer applications of 80-40-0 to 140-40-0, depending upon the basic soil fertility levels and on cropping patterns.

There is a wide differential in the yield response of the new dwarf wheats and the local tall wheats to fertilizer in Pakistan. For every pound of fertilizer nutrient (both nitrogen and phosphate) the farmer applies, he obtains 17 pounds of increased grain from the dwarf wheats as contrasted with 11 pounds from the local tall wheats. In Mexico, one pound of fertilizer nutrient applied to the commercial fields of dwarf wheat produced 23 to 28 pounds of increased grain, as contrasted with 14 to 16 pounds of increased grain from the local tall wheats in Mexico.

Those who expect to keep abreast of fertilizer production and use trends in the developing nations should keep close watch of the influence of these new varieties on farm practices. The vigorous

"farmer demand" for fertilizers in India and Pakistan will undoubtedly exert a strong influence on decisions of those governments with respect to plans for fertilizer production capacity.

Building Indigenous Research and Educational Capability

The introduction of the new high yielding wheat and rice varieties into the developing nations is directing attention of government leaders, scientists and educators, and farmers to the potentials of applied science and technology in modernizing traditional agriculture. We cannot expect, however, to supply new technology from abroad on a continuing basis any more than we could expect to furnish a constant flow of food grains, fertilizers, and other production inputs.

A.I.D. supported research projects on the nutrient status of soils in Latin America; to improve varieties of cereal crops in Africa; to improve grain legume production in Asia and the Far East; on land tenure, agricultural credit, prices, and extension and marketing systems; and on improvement of nutritional quality of food products, also are furnishing a base of understanding of the significance of science and technology in the developing countries. These projects, limited in number and in funding -- with only $14.5 million invested in such agricultural research by the Agency to December 31, 1966 -- are supplying the new cutting edge of agricultural modernization that is essential in balancing the world food budget.

It will be essential to develop an agricultural research and education institutional capability for each nation, as we built this resource in the U. S. through the establishment of the land-grant universities, the U. S. Department of Agriculture and through private enterprise.

Considerable progress has been made in establishing effective national systems of research and education in Mexico, Colombia, Peru and Chile in Latin America, and in India and other countries in Asia. Our foreign aid program has made major contributions to such institutional development efforts as have the Rockefeller, Ford and Kellogg Foundations.

As we move into a more vigorous effort in the development and application of new technology in developing nations, it is essential that we build a more effective base of cooperation from the United States. Our efforts in the past have been intermittent, and have lacked the sustained focus that is essential for institution building abroad.

A.I.D. has a large number of contracts with U. S. universities, with 127 U. S. institutions involved in 308 contracts with a total value of $202 million in the past fiscal year. It is increasingly apparent to the U. S. universities, and to A.I.D., that the demands for research and education on the domestic front preclude the allocation of well qualified scientists and educators to our foreign aid program in the numbers and for the continuing terms of involvement essential for a first-class foreign aid effort.

A.I.D. received authorization in the Foreign Assistance Act of

1966 to utilize up to $10 million of technical assistance funds to strengthen U. S. institutional capability for more effective participation in foreign aid projects but the reduction in the foreign aid budget this fiscal year precluded the implementation of this authority.

It is essential that we make firm commitments to this job, both from the standpoint of stabilized budgets, and the long range institutional commitment from A.I.D. and the cooperating U. S. institutions that will ensure a sustained effort.

Foreign Investment Opportunities

In turning to the role of private enterprise, I am sure that many of you are fully aware of the positive interest of A.I.D. in the greater involvement of the private sector.

In addition to the shipments of food grains, the U. S. foreign aid program is helping to finance substantial amounts of production inputs for the developing countries. During the fiscal year ending on June 30, 1966, A.I.D. funded about $158 million worth of such materials, including $93 million worth of fertilizers, $49 million worth of tractors and parts, $8 million worth of agricultural equipment and machinery, and $8 million worth of pesticides and other agricultural chemicals.

A.I.D. provided also over $100 million worth of development loans to the agricultural sector of developing nations for agricultural credit, irrigation and water supply projects, and farm to market roads.

A.I.D. expects to double the investment in agriculture during the current fiscal year that ends on June 30, 1967, and will approximately triple the financing of fertilizers.

The Agency for International Development provides a wide range of services to stimulate private investment in productive enterprises, and is particularly eager to encourage cooperation in enterprises related to the War on Hunger. The brochure AIDS TO BUSINESS (OVERSEAS INVESTMENT), available without charge from A.I.D.'s Office of Private Resources and from the 42 Commerce field offices in the U. S., outlines the types of assistance that can be provided.

The Catalog of Investment Information and Opportunities makes available technical economic studies regarding food production, processing, and marketing activities in developing countries. A.I.D. can pay 50 percent of the cost of a prospective investor's own survey of an investment opportunity, if no investment results.

Specific risk investment guarantees offer protection against the risks of (1) inconvertibility of foreign currency, (2) loss from expropriation or confiscation, and (3) loss due to war, revolution or insurrection. Extended risk guarantees are available to cover up to 75 percent of an investment against both political and business risks. (In recent months, A.I.D. has authorized both specific and extended risk guarantees on two fertilizer projects, one in Brazil and one in India. The investment in each project will total approximately $70 million.)

The "Cooley" loan program makes local currencies available to private American firms for financing such local costs as the expansion of plant and equipment, acquisition of land, training, and operating costs. Dollar funds can also be made available, primarily through re-lending by A.I.D.-assisted intermediate credit institutions in the developing countries.

A.I.D. is prepared to work closely with private companies in helping to identify and remove restrictive factors and to facilitate more active participation in the international War on Hunger. We have learned from our efforts to apply U. S. agricultural technology overseas that substantial adaptation and adjustments are required. In the same context, we recognize the need for malleability and adaptation on the part of American industry to a wide range of economic, political and social environments in the different nations with which we cooperate.

We appreciate also the importance of effective cooperation between the public and the private sectors, not only from the U. S. side as we plan joint ventures in the foreign aid program, but also overseas where the strong bond between the U. S. private enterprise and U. S. government agencies must be maintained as we develop effective linkages with local public and private sectors.

The World Fertilizer Production and Needs Situation

During the past 20 years, U. S. agencies have provided about

It will be essential for private industry to increase investments still further to establish the expanded fertilizer industries that will be required abroad.

A.I.D. is working closely with the Tennessee Valley Authority to maintain current information on fertilizer production capacities and requirements on a world-wide basis.

Present estimates by TVA are that in order to maintain even the present dietary levels, fertilizer use should be increased from the 40 million metric tons used in 1965 to 71 million metric tons by 1971, and to 112 million metric tons by 1980. These estimates, of course, may prove to be conservative if demands for food increase as a result of greater purchasing power of individuals in developing societies.

It is believed that adequate production capacity is being constructed or planned on a world-wide basis to meet the fertilizer needs into the 1970s. More than 109 million metric tons of capacity on a plant nutrient basis is in sight, as compared with the estimates of about 71.0 million metric tons of plant nutrients required by 1971.

While the 109 million metric tons is the estimate of announced capacity, it is expected that because of project delays and cancellations there will be less than this capacity in actual operation by 1971. It is recognized also that some of the new construction is for replacement

Although capacity on a world basis appears to be adequate through 1971, its location leaves much to be desired. It is estimated that the developing regions (including all of Asia except Russia, all of Latin America, and all of Africa) should be using a minimum of 22 million metric tons of plant nutrients if they are to meet their minimum dietary levels by 1971. But they will have a production capacity of no more than 20.4 million metric tons if all of their announced planned capacity becomes operational.

If this plant capacity is operated at only an 80 percent level, which is still in excess of what has been experienced to date in some of the developing countries, their deficit would be 5.7 million metric tons of plant nutrients. This compares with imports of 3.4 million metric tons by the developing countries in 1965.

It is expected that the developing nations will continue to increase their share of the world fertilizer production capacity. From 1955 to 1965, they increased from 8 percent to 10 percent and it is predicted that by 1971 they may have as much as 18 percent, including 23 percent of the N capacity, 22 percent of the P_2O_5 capacity, and about 5 percent of the K_2O capacity. Distributed according to population, this will still mean that 70 percent of the world's population will have only 18 percent of the world's fertilizer production capacity.

The Costs and Returns in Foreign Aid

We fully anticipate searching inquiries this year into the degree of involvement of the U. S. Government in activities abroad. The record federal budget of $169.2 billion proposed for fiscal year 1968 includes a national defense military budget of approximately $74.7 billion, with $22.4 billion for the military effort in Vietnam. The foreign aid budget of $2.4 billion is modest by comparison but its significance far outweighs the relative expenditure or investment.

As Secretary Freeman stated recently, "A hungry world is a dangerous world. Without enough food 2 billion hungry people represent the greatest threat to our way of life; they are the spawning grounds of riot, armed conflict, and civil war. As long as these billions are hungry or malnourished, there is no security -- for Americans or anyone else."

We cannot fully assess the impact of modest investments now -- in peace time economic and agricultural development efforts -- in terms of future insurance against larger expenditures of the type we have today in Vietnam. We are aware, however, of the need to help establish stable political systems that cannot be built in hungry nations.

We do have concrete evidence of the mutual economic benefit from our cooperation in international development programs. A measure of the returns to American agriculture from foreign aid investments is furnished

through the results of our cooperation with Japan, Israel, Spain and Taiwan. All of these countries are now on their own, and receive no economic aid from the United States. All of them have achieved, for the past decade or more, agricultural growth rates substantially above our own. They range from the 2.7 percent average annual growth in agricultural productivity for Spain during 1948 to 1963, to 2.8 percent for Japan, 4.4 percent for Taiwan, and a phenomenal 9.7 percent for Israel. In all of these countries, we have carried out energetic export promotion activities financed by PL 480 currencies.

These countries, which built their economies on strong agricultural underpinnings, have become the best cash customers for American agriculture during the period from 1960 to 1965. Taiwan increased its commercial imports of American farm products by 243 percent. Israel, in spite of its own spectacular farm production growth, still increased its imports of our farm products by 305 percent. Spain increased its imports by 615 percent, reaching a total of $148.5 million last year. And Japan increased her imports of American farm products by 182 percent -- to a total of $865.5 million -- to become, by a wide margin, our best customer. This has happened in just five years and suggests the potential for American agricultural trade if we strengthen our programs to assist other developing countries to achieve similar capacities to buy our farm products.

President Johnson, in his Message on Foreign Aid on February 9, in referring to "the long hard struggle to bring the majority of the world's population out of the shadows of poverty and ignorance", pointed out "that we are dealing in decades with the residue of centuries. There is no short cut. There is no easy way around. The only effective tools are ingenuity, capital and, above all, the will to succeed".

I believe we might add modern technology as one of the prime development components. We should recognize food aid as a transitional and temporary policy, to be supplanted as rapidly as possible by the long range policies which are based on effective inputs of science and technology, and the development of indigenous institutions that will furnish steady and sustained growth for developing nations.

A.I.D. Administrator William Gaud considers the world food problem and the War on Hunger "the highest functional priority in A.I.D.'s total range of program operations". The modernization of agriculture on a world-wide scale will require a sustained intensive effort and we must commit our necessary foreign aid resources on a long range basis for this long range task.

References

1. Bogue, Donald J. "Curbing Fertility in Developing Countries: An Evaluation of Opportunities and Programs". Conference on Alternatives for Balancing Future World Food Production and Needs, Iowa State University, Ames, Iowa November 8, 1966

2. Borlaug, Norman E. Personal Correspondence September 20, 1966

3. "Estimated World Fertilizer Production Capacity as Related to Future Needs". Tennessee Valley Authority, Muscle Shoals, Alabama February, 1966

4. Ewell, Raymond "Population Growth and Birth Control" Journal of International Health, Volume 2, No. 1. Fall, 1966

5. Ewell, Raymond "Population Outlook in Developing Countries" Dinner Address - Annual Meeting of the Agricultural Research Institute, National Academy of Sciences-National Research Council, Washington, D. C. October 10, 1966

6. Heady, Earl O. and Timmons, John F. "Objectives, Achievements, and Hazards of U. S. Food Aid and Agricultural Development Programs in Relation to Domestic Policy" Conference on Alternatives for Balancing Future World Food Production and Needs, Iowa State University, Ames, Iowa November 8, 1966

7. "Internationalizing Food Aid" Editorial, The Washington Post, February 3, 1967

8. Kirkpatrick, Carroll "More Grain is Allocated for India" The Washington Post February 3, 1967

9. McCune, D. L. The Tennessee Valley Authority, Personal Correspondence January 19, 1967

10. Narvaez, Ignacio and Qureshi, S. A. Annual Technical Report, Accelerated Wheat Improvement Program, West Pakistan, 1965-66. Agriculture Department, Government of West Pakistan, Lahore August, 1966

11. "Outlook for A.I.D. Programs: BOOM!" Farm Chemicals, January 27, 1967

12. The Outlook for Grain in 1970. Report of the Foreign Regional Analysis Division, Economic Research Service, U.S.D.A., Washington, D. C. December 29, 1966

13. The World Food Budget, 1970. Economic Research Service, U.S.D.A. Washington, D. C. 1964

14. West, Quentin M. "World Food Needs" Economic Research Service, U. S. Department of Agriculture February, 1966

EFFORTS TO INCREASE WORLD WHEAT PRODUCTION

I appreciate this opportunity to review with you some of the prospects and problems in meeting expanding world-wide wheat requirements. It is most fitting for the Crop Quality Council to extend its focus to international horizons, from the excellent base of service to American agriculture.

The Council, and its predecessor organization -- the Rust Prevention Association -- has for many years furnished a respected communications link between farmers, the industries related to agriculture, the Congress, and scientists and educators. It has not only strengthened research to protect U.S. crops from the hazards of pests and diseases, but also has helped to counter the restricted views of those who would have cut agricultural science and technology during those years when we were producing more wheat and other grains than domestic and foreign markets could absorb.

There is still considerable divergence of opinion about the degree of crisis in the world food situation. The substantial reductions in food grain production in India resulting from the short monsoons of 1965,

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Presented by Dr. A. H. Moseman, Assistant Administrator for Technical Cooperation and Research, Department of State, Agency for International Development, at the Annual Meeting of the Crop Quality Council, Minneapolis, Minnesota

February 8, 1967

and from continued drought in certain areas in 1966, have sharpened up attention to world population growth and food supplies. The draw-down of world grain stocks, with strict rationing of U.S. supplies for the food grain deficit countries, is causing a sober assessment of the demand and supply situation on a world-wide basis. We can expect differing judgments in the next few years as information-gathering procedures are improved and as we gauge the production plans and capabilities of other food grain surplus nations.

World Population Projections

We are well aware of the warnings of massive starvation in many current food deficit areas within the next few years. Dr. Raymond Ewell, Vice President for Research at the State University of New York at Buffalo, has been most persistent in forecasting a falling domino pattern of hunger and starvation, moving from Asia into Latin America over the next two decades unless family planning and food production efforts are addressed more vigorously. The Food and Agriculture Organization report for 1966 calls attention to the continuing shortfall in international food production, with world population increasing by 70 million during the past year and world food supplies down by 4 to 5 percent on a per capita basis.

A few demographers sound a note of optimism. Dr. Donald J. Bogue, Director of the Community and Family Study Center of the University of Chicago, suggested recently that "The trend of the world-wide movement

toward fertility control has already reached a state where declines in death rates are being surpassed by declines in birth rates". He estimates that the time in which this "switchover" took place was about 1965 and that we may expect world population growth rates to decline annually in the future. Dr. Bogue suggests that "the rate of growth will slacken at such a pace that it will be zero or near zero at about the year 2000, so that population growth will not be regarded as a major social problem except in isolated and small, 'retarded' areas".

While I would not profess to judge the respective projections of Dr. Ewell and Dr. Bogue, I believe the experience of the past two years in trying to establish effective family planning programs in India and other countries in Asia, as well as in Latin America, suggests that we guard against premature complacency. The recent calculations of growth rates in various parts of the world point up the extremely rapid increase in Costa Rica where the population is expected to double in the next 16 years and in Mexico, where the 40 million people may double in 20 years.

World Food Production Trends

The U.S.D.A.'s Economic Research Service furnished commodity projections in "The World Food Budget, 1970", which was published in 1964, and has continued to update these estimates.

Recent trends are helpful in assessing what we may expect in the years ahead. The less developed countries (including Communist Asia, but

excluding Argentina) exported about 3 million metric tons of grain prior to World War II, but will import around 33 million metric tons this year.

The rate of increase in food production in the less developed countries over the past thirty years is approximately 2 percent annually, similar to the rate in the developed nations. But, in the less developed countries about 65 percent of the increase has been abosrbed by expanding populations.

Food production per capita in the Far East (excluding China) has leveled off, although there was considerable improvement during the latter part of the 1950s. There has been some increase in production in Latin America in recent years; but in Africa and the Middle East production has remained about even with population growth.

The Outlook for Grains in 1970

In a report released on December 29, 1966, the Economic Research Service of the U.S.D.A. concludes that "by 1970 the world supply of wheat will be more than adequate to meet effective demand at prices not far different from present levels". This assumes that the Soviet Union will succeed in increasing its production and that there will be no major droughts in the large wheat exporting or importing countries.

The unusually large shipments to India in 1966, when we supplied approximately 9 million metric tons to alleviate the food shortages resulting from the severe drought, reduced U.S. stocks substantially.

Supplies of wheat held by other major exporting countries also were cut down because of the large import demands from Communist China and the U.S.S.R.

Production of wheat on a world-wide basis increased significantly in 1966, however, and it is expected that there will be a substantial increase in world carry-over stocks in 1967. The record production of 274 million metric tons in 1966 resulted from both increased acreage and higher yields.

Canada produced 23 million metric tons of wheat in 1966, 16 percent higher than the previous record of 1963. The area seeded to wheat in Canada has extended by 1/3 during the past ten years to 12.3 million hectares in 1966. The use of fertilizer quadrupled from 1957 to 1965, and price support policies also have been favorable.

In Australia, the wheat area more than doubled during the past ten years, to 8.3 million hectares, and it is estimated that production will reach a record of 11 million metric tons. Applications of superphosphate fertilizer on wheat lands have leveled off in Australia since 1958, although yields per acre resulting from such heavier fertilizer use have been offset by pushing wheat production onto less productive lands.

The wheat crop of the Argentine, estimated at 8.5 million metric tons for this year, has been exceeded in only two of the past ten years. The acreage planted to wheat in the Argentine is currently about 20 percent

above the average for 1955-59. The use of improved varieties has expanded in the Argentine but the application of fertilizer is still negligible.

The optimistic outlook for 1970 is based in large part on the expectation that production in the U.S.S.R. will continue to increase through expanded use of fertilizers, machines and capital. The use of fertilizers applied to grain was about 12 million tons in 1966 as contrasted with 6.5 in 1964 and 1.3 in 1958. In comparing 1966 with 1958, machinery inventories were 75 percent higher for tractors, 50 percent higher for trucks, and 8 percent larger for combines. The capital investment in agriculture in 1966 was about double that of 1958.

The U.S.D.A. report suggests that the level of our agricultural exports within the next decade will be determined more by demand and U.S. policy then by the productive capacity of the United States. It is recognized that prior to 1966 the U.S. deliberately followed a policy of reducing stocks from the level of 38 million metric tons in 1961 by restricting production and increasing concessional exports to developing countries. There has been no upward trend in U.S. wheat acreage during the past decade, while our competitors have greatly expanded their wheat acreage and production.

The shift in U.S. policy, to increase production for expanding world needs, is reflected in the decisions by the U.S.D.A. announced in

May and August, 1966 to increase wheat acreage by about 16.6 million acres, to a total allowable acreage for harvest in 1967 of 68.2 million.

It is expected that total U.S. wheat exports may rise from the average of 20.6 million metric tons during the past 5 years to about 24 million metric tons in 1970. This includes 18 million metric tons to the less developed nations, 1.7 million tons to Western Europe, 1.8 million tons to Eastern Europe and over 2 million tons to Japan.

Foreign and domestic requirements will total about 44 million metric tons, about 30 percent above the 1964-65 crop of 35 million. It is estimated that with favorable weather, continued progress in increasing yields, and the added acreage U.S. wheat production could reach 48 million metric tons by 1970, enough for export and domestic needs as well as for adequate reserve stocks.

It is not possible to present meaningful details on all specific factors, but I believe the foregoing resume suggests the type of assessment that is being made continually by the U.S. Department of Agriculture to furnish production and demand guides. For those of you who wish more precise information, I would refer you to Dr. Quentin N. West, Director of the Foreign Regional Analysis Division, Economic Research Service of the U.S.D.A. in Washington.

Although we may regard the projections for food grain production over the next three to five years as reasonably optimistic, we are well aware of the many uncertainities in the assumptions on which these

projections, and the longer-range forecasts, are based. We cannot expect that the weather will be favorable everywhere and every year.

As Dr. Eugene B. Hayden of the Crop Quality Council pointed out in his testimony before the National Advisory Commission on Food and Fiber on September 15, 1966, the reduction in U.S. winter wheat production by more than 130 million bushels in two months in the spring of 1966, from extensive drought and frost injury, serves as a reminder of the complex biological factors that influence agriculture, with the uncertainties of weather, plant diseases, and insect pests.

We can anticipate increasing hazards from disease and insect outbreaks in the developing nations as they intensify production through introduction of new crop varieties and use of higher levels of fertilizer.

The exploitation of added crop acres, whether in the "new lands" of the U.S.S.R. or in the uncertain rainfall regions of Australia, will undoubtedly contribute to wide fluctuations in world wheat production in the years ahead.

Increasing Food Production in Developing Nations

President Johnson, in his State of the Union Message on January 10, 1967 said, "Next to the pursuit of peace, the greatest challenge to the human family is the race between food supply and population increase. That race is now being lost."

The President called attention to the continuing decline in grain stocks, with increasing numbers of developing nations becoming

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of algae, and harvesting potential food resources from the sea and from the jungles.

These are all exciting prospects but when we recognize that yields of crops and livestock in most food deficit nations are only 25 to 30 percent of those of agriculturally advanced nations, we would be well advised to improve first the production of conventional foods. The first priority should be to increase production of the foods that people want to eat, by doubling or trebling the yields of these products from land and labor resources that are not now efficiently utilized, through application of science and technology that has been proved not only in the United States but in Mexico, Taiwan, and in other developing nations.

We do not, of course, have a ready formula for agricultural modernization and are well aware of the tendency to over-simplify the agricultural sector of a developing economy. The growth and development of our highly productive agriculture in the United States has occurred as an evolutionary process, through several decades and centuries, and it is difficult to put into sharp focus those factors of greatest significance.

Guidelines for a strategy of agricultural development have been developed by a number of agricultural specialists which, while varying in emphasis, usually embody the following basic components:

A. General government policies and services, including budget allocations to agriculture; capability for program analysis and planning; import-export policies; and decisions with respect to price incentives, land tenure, taxes, and agricultural credit.

B. New technology, including research, extension and education, with special attention to the development and introduction of improved strains or breeds of crops and livestock and practices for their production; and the establishment of effective systems of research, education and extension to insure the constant flow of innovations for continuous growth in the agricultural sector.

C. Physical inputs for production, including fertilizers, pesticides, and machines, with appropriate attention to their marketing, distribution, and cost, as well as availability.

D. Markets and related services, including domestic and foreign outlets; adequacy of marketing systems, transportation, and storage, and the processing organization and facilities.

E. Institutions, for national programs of research, education and extension; local self-government; cooperatives; rural credit; and the farm organizations or associations that are essential to help guide changes in production systems, tenure arrangements, etc.

F. General infrastructure, including transport, power, communications and related services; health services, industrial investments, including private enterprise; and general education to facilitate economic, political and social advance in the rural as well as urban societies.

We are in the process of reviewing the agricultural sectors of a number of the major countries that are in a food deficit situation, to determine where our limited resources for technical assistance and economic aid best might be applied.

New Technology

Although we appreciate the advantages of a "balanced approach" in addressing all of the components or elements outlined above, we are fully aware that the lag is greater in certain areas of the agricultural sector than in others. One such component is the application of science and technology.

The "Point IV Program" established under the Act for International Development, Public Law 535, approved on June 5, 1950, directed U. S. international cooperation more vigorously toward those countries that have been classed as "poor, tropical, and agricultural". As this new venture was undertaken, it was assumed that economic development of the cooperating countries could be achieved rather promptly and simply by the transfer of materials and knowledge from advanced U. S. science and technology. Major emphasis was placed on furnishing U. S. advisors to help establish extension and rural development programs to disseminate such materials and practices.

It has become increasingly clear that much of our U. S. experience or material does not fit the agriculture of the tropics and cannot be directly "adopted". The growing emphasis on "adaptive research" as an essential element in the technical assistance efforts for agricultural development during the past year reflects the recognition that modifications in crop plant varieties, methods of pest control, soil and water management, and agronomic practices must be made to suit local growing conditions if dependable increases or changes are to be achieved in agricultural development.

The strong "extension orientation" in the U. S. foreign aid effort since the initiation of the Point IV program in 1950 resulted in only limited attention to the new technology component, or the research input in the development process. Considerable progress has been made, however, in rural development, in establishing community organizations and methods of communications.

One of the first, and certainly one of the most effective, efforts to stimulate agricultural growth and development was the cooperative program initiated by the Rockefeller Foundation and the Government of Mexico in 1943. This program concentrated on the improvement of the basic food crops through research and education. Many of you are familiar with the record of economic development in Mexico, including the increase in wheat production as reflected in the change in per acre yields from about 11 bushels in 1943 to over 39 bushels in recent years.

The research on wheat production in Mexico, which in later years was extended into Colombia, Chile, and elsewhere in Latin America, as well as to Africa, the Near East, and South Asia, furnishes a real measure of the significance of new crop production technology in agricultural development.

The "Mexican wheats" which are non-photosensitive and, therefore, can grow well under a wide range of day length conditions, may well become the most important single factor in increasing world food production during the decade through 1975. These varieties grow to about thirty to forty inches in height, have stiff straw, and can convert large quantities of nitrogen and other plant nutrients into high yields without lodging.

The purchase of 18,000 tons of seed of the Mexican wheats in August, 1966 by the Government of India from the Government of Mexico represents the largest international shipment of the seed stock of a major

food grain in history. This seed, together with that produced in India during the past year, will enable India to plant approximately 1 million acres to the Mexican wheat varieties in 1966-67. It is estimated that next year India may have 40 to 50 percent of her wheat crop in these varieties.

The Government of Pakistan, in an effort to achieve self-sufficiency in wheat production by 1970, also is depending heavily upon the high-yielding capability of the Mexican wheats. In a project supported by the Ford Foundation, the West Pakistan Government imported in June, 1965 about 350 tons of seed of the Mexican dwarf wheats, Penjamo 62 and Lerma Rojo 64. There will be about 500,000 acres planted next year to these varieties.

In both India and Pakistan, research and testing is underway to improve fertilization and water management practices, and on planting methods and other agronomic practices to achieve maximum yields.

Dr. Orville Vogel, of the U.S.D.A.'s Agricultural Research Service, who returned recently from Turkey where he served on a team of U. S. specialists studying possibilities for improving the agriculture of that country, reported that one of the most encouraging developments is the performance of the "Sonora wheats" in the Adana area. About 60 tons of seed of these semi-dwarf wheats have been planted by more than 100 farmers scattered over a wide region. The results of earlier trials have been so outstanding that farmers have travelled more than 200 miles to observe the planting and to obtain seed.

It is estimated that Turkey could produce up to 1 billion bushels of wheat, as contrasted with current production of about 400 million bushels, through the development of further improved varieties and associated research in plant disease and pest control, better soil moisture conservation and drainage practices, and more effective use of fertilizers and chemical weed control.

The impact of self-sufficiency in wheat production in Turkey is indicated by the level of annual Turkish wheat imports which, since 1960, have ranged from no imports to almost a million metric tons.

The International Maize and Wheat Improvement Center, in cooperation with Mexico's National Institute of Agricultural Research and the FAO, has conducted cooperative spring wheat yield trials since 1961 in eleven countries in the Near East and Africa, as well as in Mexico and Colombia. The 25 varieties included in the tests are representative of the principal types of spring wheats seeded in the Near East, Mexico, Colombia, and the Argentine. The tests were conducted in Turkey, Ethiopia, Sudan, Egypt, Jordan, Lebanon, Syria, Iraq, Iran, Pakistan, India, Colombia, and Mexico.

The seven highest yielding varieties in these tests, from the average of three years, were from the Mexican selections, with an Australian and an Egyptian wheat also among the ten highest yielding varieties. These tests demonstrated that varieties which respond to good management and near optimum conditions will perform in a similar outstanding manner

also under low fertility and less favorable growth conditions. The top ranking varieties at the four high yielding sites also were outstanding in the four lowest yielding sites. The tests were conducted over a wide range of conditions ranging in altitude from 2,600 meters above sea level in Colombia to 243 meters below sea level in Jordan, with fertilized and unfertilized as well as irrigated and non-irrigated plots.

Through these cooperative yield trials, together with the training of substantial numbers of young plant breeders from the Near East countries in Mexico under the program supported by the FAO and the Rockefeller Foundation, an excellent regional wheat improvement research program is in process of development for the Near East, South Asia, and African countries. The A.I.D. Mission Directors and agricultural specialists in Afghanistan, Nepal, Jordan, Morocco and Tunisia have expressed interest in improving their cooperative wheat production programs through the adaptation and use of the high-yielding wheats that have been developed through the cooperation of the Rockefeller Foundation and the ministries of agriculture in Mexico, Colombia, and Chile during the past twenty years.

These wheats, with their outstanding performance under widely variable growing conditions, may well furnish the thrust of new technology into modernization of international agriculture that hybrid corn supplied for domestic agriculture 35 years ago.

U.S. "Self-Interest" and LDC "Self-Help"

A question that confronts all of us who are involved in

international agricultural development is the possible deleterious effect on the agricultural industry of the United States. We are fully aware of the difficulty in justifying the expenditure of U. S. taxpayer dollars for developments overseas that will hurt our domestic economy.

Secretary Freeman, in addressing a meeting of the Association of State Universities and Land-Grant Colleges last November recognized that "The American people will not accept our doing a job abroad unless we do our job at home."

Members of Congress from agricultural states have exerted a strong influence on the force and direction of U. S. cooperation to improve agricultural development abroad in the past decade. The build-up of agricultural commodities in the United States, including wheat and rice, following the Korean War caused a definite restraint on U. S. efforts to assist developing nations to produce more food. This has been particularly true with respect to the establishment of cooperative research programs to increase production of wheat, rice, and other commodities in surplus in the U. S.

The nature and depth of our self-interest, and a determination of the efforts that will best serve the economic, social and political interests of the world community of nations requires full assessment.

It is increasingly apparent that we cannot hope for a peaceful and orderly world when half of its people suffer, constantly, the pangs

of hunger and ravages of disease encouraged by malnutrition. Improved communication increases awareness around the world that hunger is not universal and that it need not necessarily be accepted. Food riots or civil disorders may not be directed specifically against nations whose peoples have more than adequate diets, but as such revolts overthrow friendly local governments we may be caught up in the outwash of the unstable and perhaps even hostile political systems that result.

In addition to the moral issues in equalizing opportunities for more adequate nutrition, improved health services, and literacy, and the contribution to world peace and stability, we should assess the mutual economic benefit from expanded cooperation in agriculture. The prosperity of American agriculture depends upon a high level of commercial export business. The ability of other nations to purchase food and agricultural products from us depends upon their general economic development. In spite of the fact that it is the poor countries which are hungry, it is the economically viable countries to whom we sell our food.

It is estimated that our 1966 agricultural export sales totalled about $7 billion, including cash sales of $5.4 billion. They are expected to rise to $8 billion by 1970 and to $10 billion by about 1980.

Evidence of the returns to American agriculture from foreign aid investments is furnished through the results of our cooperation with

Japan, Israel, Spain, and Taiwan. All of these countries are now on their own, and receive no financial aid from the United States. All of them have achieved, for the past decade or more, agricultural growth rates substantially above our own. They range from the 2.7 percent average annual growth in agricultural productivity for Spain during 1948 to 1963, to 2.8 percent for Japan, 4.4 percent for Taiwan, and a phenomenal 9.7 percent for Israel. In all of these countries, we have carried out energetic export promotion activities financed by PL 480 currencies.

These countries, which built their economies on strong agricultural underpinnings, have become the best cash customers for American agriculture during the period from 1960 to 1965. Taiwan increased its commercial imports of American farm products by 243 percent. Israel, in spite of its spectacular farm production growth, still increased its imports of our farm products by 305 percent. Spain increased its imports by 615 percent, reaching a total of $148.5 million last year. And Japan increased her imports of American farm products by 182 percent -- to a total of $865.5 million -- to become, by a wide margin, our best customer. This has happened in just five years and suggests the potential for American agricultural trade if we strengthen our programs to assist other developing countries to achieve similar capacities to buy our farm products.

The building of self-help capability for food production in the developing nations requires a sustained, well-planned, and positively-directed effort. The War on Hunger will not be won by new slogans or pronouncements.

It is essential that we develop better mutual understandings of the magnitude of the task and decide whether we are willing to make a wholehearted effort in meeting the challenge. Today, those responsible for planning and organizing the U.S. foreign cooperation effort in world food production are faced with a continuous running of the amber light of uncertainty about the degree of U.S. commitment.

Without a firm commitment from the American people, and from the Congress, and the green light to move vigorously, we face the very real prospect of an effort that will continue to be halting and uncertain -- with an image of feebleness and futility -- in the agricultural development sector in which we are unexcelled in the world.

References

1. Bogue, Donald J. "Curbing Fertility in Developing Countries: An Evaluation of Opportunities and Programs". Conference on Alternatives for Balancing Future World Food Production and Needs. Iowa State University, Ames, Iowa. November 8, 1966.

2. Borlaug, Norman E. Personal Correspondence. September 20, 1966.

3. Ewell, Raymond. "Population Growth and Birth Control". Journal of International Health, Volume 2, No. 1. Fall, 1966.

4. Ewell, Raymond. "Population Outlook in Developing Countries". Dinner Address--Annual Meeting of the Agricultural Research Institute, National Academy of Sciences--National Research Council. Washington, D. C. October 10, 1966.

5. Hayden, Eugene B. Statement to the National Advisory Commission on Food and Fiber. September 15, 1966.

6. Narvaez, Ignacio, and Qureshi, S. A. Annual Technical Report, Accelerated Wheat Improvement Program, West Pakistan, 1965-66. Agriculture Department, Government of West Pakistan, Lahore. August, 1966.

7. Ruttan, Vernon W. "Are Grain Surpluses a Thing of the Past?" Annual Meeting, Minnesota Plant Food Association. Minneapolis, Minnesota. November 29-30, 1966.

8. West, Quentin M. "World Food Needs". Economic Research Service. U. S. Department of Agriculture. February, 1966.

9. The Outlook for Grain in 1970. Report of the Foreign Regional Analysis Division, Economic Research Service, U.S.D.A., Washington, D. C. December 29, 1966.

10. The World Food Budget, 1970. Economic Research Service, U.S.D.A. Washington, D. C. 1964.

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THE ROLE OF SCIENCE AND TECHNOLOGY IN MEETING WORLD FOOD NEEDS*

There is still a wide difference of opinion about the degree of crisis in the world food situation. Judgments range from the very discouraging assessment presented by William and Paul Paddock in their book Famine 1975 to the optimistic view that food production will keep pace with needs in the years ahead, aside from local shortages caused by unfavorable weather such as the deficient monsoons in India in the past two years.

The most thorough assessment of the world food problem available today is presented in the report of the Panel on the World Food Supply of the President's Science Advisory Committee, released in May, 1967. The Panel presents four principal findings and conclusions:

> (1) The scale, severity, and duration of the world food problem are so great that a massive, long range, innovative effort unprecedented in human history will be required to master it.
>
> (2) The solution of the problem that will exist after about 1985 demands that programs of population control be initiated now. For the immediate future, the food supply is critical.
>
> (3) Food supply is directly related to agricultural development and, in turn, agricultural development and overall economic development are critically interdependent in the hungry countries.
>
> (4) A strategy for attacking the world food problem will, of necessity, encompass the entire foreign economic assistance effort of the United States in concert with other developed countries, voluntary institutions, and international organizations.

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* Presented by Dr. A.H. Moseman, Agricultural Development Council, 630 Fifth Avenue, New York, N.Y. at the Annual Meeting of the American Phytopathological Society and the Society of Nematologists, Washington, D.C., August 21, 1967.

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Other pertinent conclusions of the panel are: (1) the vast majority of the increased production must take place within the developing countries themselves; (2) the bulk of the increase in food supply must come from increased production of farm crops; (3) in Asia, a shift to increasing crop production by intensifying agriculture and using modern methods to improve annual yields on land under cultivation will be mandatory; and (4) critical to the success of all of these measures is an effective program of adaptive research to gain an understanding of the principles governing plant and animal production under the conditions, soils, and climates existing in the developing countries.

The panel report also emphasizes that "increasingly, United States foreign assistance should take the form of knowledge, technical aid, adaptive research, education, and institution building." The panel stated firmly that "long-term committment of substantial resources is an absolute necessity. The fallacious notion that foreign aid's main business is to put itself out of business should be dropped for the remainder of this century."

Our experience in technical cooperation during the past 15 years has given us a deep appreciation of the complexity of the job of upgrading agriculture in the developing nations. The many factors that interact have been identified in various ways by different specialists in international agriculture. Dr. Arthur T. Mosher, President of the Agricultural Development Council, in his book Getting Agriculture Moving recognizes five "essential" facilities and services for agricultural development, as:

(1) Markets for farm products

(2) Constantly changing technology

(3) Local availability of supplies and equipment

(4) Production incentives for farmers

(5) Transportation

The order of listing has no significance with respect to the importance of each. In addition to the foregoing "essentials," Dr. Mosher identifies five "accelerators" or factors that are important but not indispensible, as:

(1) Education for development

(2) Production credit

(3) Group action by farmers

(4) Improving and expanding agricultural land

(5) National planning for agricultural development

The Significance of "New Inputs" in Agricultural Development

Although we recognize that science and technology alone cannot accelerate agricultural development, there is a growing appreciation on the part of leaders in developing nations that new inputs must be made in agriculture to achieve increased production. Dr. Ralph W. Cummings of the Rockefeller Foundation, in reviewing the prospects for agriculture in India in February, 1967, stated,

> "the conviction has emerged that the food problem will be met and solved only through a massive application of science and technology to agricultural production, the mobilization to provide the

> necessary physical inputs such as fertilizer, crop protection chemicals, improved seeds, implements, credit, etc., and the gearing up of its research and training institutions to provide the scientists with a production orientation to assure sustained progress. The very able and dynamic Minister for Food and Agriculture, Mr. C. Subramaniam, has taken a vigorous lead in this program, and there appears to be emerging among farmers, seed producers, and others throughout the country a feeling of hope and optimism that they now see the possibility of overcoming their current crisis. I feel that there is a major agricultural revolution underway in India which even as recently as two years ago was not clearly evident."

The inputs of improved varieties, fertilizers, pesticides, and implements are costly and they must provide sure returns. Research is essential, therefore, not only to ensure fool-proof innovations for farmers but also to guide the establishment of agribusiness to serve commerical agriculture in developing nations.

Mr. Charles Siverd, Vice President of the American Cyanamid Company and Chairman of the Board of Directors of the National Plant Food Institute, stated at the Midwest Fertilizer Conference last February, "A prosperous agriculture cannot long exist in a climate of waning research emphasis." He stressed "the need to improve the 'fit' of nutrient applications more accurately to individual soil and crop requirements." This judgment of sophisticated agricultural industry leadership of the importance of production research in the U.S. applies even more crucially to agriculture in developing nations where there is little or no experience or experimentation to guide efficient use of purchased inputs in farming.

In considering the role of science and technology for agricultural improvement we might focus on the following three facets or aspects: (1) adaptive research, to modify and fit scientific advances of developed countries to specific conditions or requirements in the developing

nations; (2) the establishing of channels or procedures for the orderly transfer of technology from the advanced to the developing nations; and (3) the building of the indigenous national institutional capability for science and technology in agriculture, including research, education and extension.

Adaptive Research

We are still guilty, in too many instances, of a "grab bag" approach in attempting to transfer our temperate zone agricultural technology to the cooperating developing nations which are largely in the tropics. But, the more capable professional agriculturists recognize the need to modify and adapt materials and practices to specific growing conditions.

Adaptive research was a dominant factor in the development of U.S. agriculture. Most of the crop plants introduced from abroad were rather poorly suited to conditions in our farming regions. It was the modification through research, to incorporate disease resistance and other desired characteristics, that brought out the full productivity of introduced plants. One of the most striking recent examples is the transformation of the soybean into a solid crop component in our agricultural industry. This has been accomplished during the past 25 years through a well organized program of interdisciplinary research in plant breeding, in disease and pest control, and in agronomic practices, including soil and water management.

The most successful application of science and technology for agricultural improvement in the developing countries has been furnished by the agricultural sciences program of the Rockefeller Foundation. The

Foundation's initital venture into agricultural improvement, in Mexico in 1943, emphasized research to improve production of the basic food crops, wheat, corn, potatoes and beans.

Wheat production in Mexico had been inadequate to meet domestic needs ever since the crop was introduced by the Spaniards, in about 1520. Since 1956, after thirteen years of cooperative research guided by the Rockefeller Foundation staff, Mexico has produced sufficient wheat for domestic needs, and in recent years, has had some surplus for export. This achievement involved almost a four-fold increase in production per acre and the self-sufficiency has maintained even though the population of Mexico has doubled since 1943.

Today, the improved wheats developed through the cooperative program in Mexico are making a major impact in the food deficit nations of India, Pakistan and Turkey. In August, 1966 the government of India imported 18,000 tons of seed of the Mexican wheats, at that time the largest international shipment of seed of a major food grain in history. In May, 1967 the government of Turkey arranged to purchase 19,600 tons and the government of Pakistan purchased about 40,000 tons of seed of these short-strawed, early-maturing varieties that have the capability to utilize more than 100 pounds of nitrogen per acre to produce yields that are 3 to 4 fold those of the local strains or varieties.

The international impact of the Mexican wheat improvement program is most significant and spectacular but this experience can be replicated or repeated for other crops in other food grain deficit areas of the world. The increased wheat yields were achieved through the relatively simple process of (1) introducing outstanding plant germ plasm from abroad,

and (2) adaptive research to incorporate disease resistance and other characteristics to suit the introduced materials to specific local environments.

The science of plant pathology played a prominent role in Mexican wheat improvement since the major limiting factor through the years had been the heavy losses from stem rust and periodic outbreaks of leaf rust and stripe rust. The initial stem rust resistant wheats introduced into Mexico by the cooperative program were selected from hybrids furnished by the late Dr. E.S. McFadden of the U.S. Department of Agriculture that carried the Hope type of resistance. Other locally adapted rust resistant varieties were selected from wheats introduced from Kenya.

The climate of Mexico permits the growing of two segregating or breeding generations annually and by 1949 four hybrid varieties had been developed including Yaqui, Naza, and Chapingo, from crosses of Marroqui x Newthatch; and Kentana, from the cross of Kenya x Mentana. Marroqui and Mentana were Mexican varieties and the other parents were, of course, introduced varieties with a high degree of rust resistance. In 1951, when these varieties constituted 70% of the wheat acreage in Mexico, the outbreak of race 15B of stem rust caused heavy damage to the varieties with the Hope type of resistance. The varieties carrying the Kenya resistance successfully withstood the disease.

In 1953, stem rust race 139 caused heavy damage to the varieties with Kenya parentage. Races 29, 48, and 49 also were serious threats so the research program to improve wheat production in Mexico has had a continuing strong orientation to breeding for disease resistance, with

attention also to strength of straw, high yielding capability, and to soil fertility and water management.

The present group of "Mexican Wheats," Sonora 63, Sonora 64, Lerma Rojo, Pitic 62 and Penjamo 62, which have proved so widely adapted are the product of this continuing cycle of adaptive research, drawing upon foreign germ plasm to combine with locally adapted varieties. These new dwarf or semi-dwarf varieties inherited their short stature and exceptional yielding capability from the variety "Norin" which was introduced into the U.S. from Japan in 1947 by Dr. S.C. Salmon of the U.S. Department of Agriculture. The Norin wheats have been used also in the Pacific Northwest in the breeding of the variety Gaines, which has produced more than 200 bushels per acre.

Adaptive research is continuing with these Mexican wheats as they are moved into new environments. Indian and Pakistani farmers and consumers prefer a white grain so the red-grained Mexican varieties have been crossed with local varieties in these two countries to produce locally adapted, white-grained types. Continuing attention is necessary also to insure resistance to the new virulent forms of rusts and other diseases that can be expected to emerge as widespread plantings are made of the new wheat introductions in the Near East and South Asia. Studies on planting methods, soil fertility and water management, as well as disease and pest control measures, are also under way.

The outstanding contribution of the International Rice Research Institute, which was organized in the Philippines in 1960 through cooperative support from the Ford and Rockefeller Foundations and the government of the Philippines, also is based on a strong adaptive research

program. The initial step was the collection and evaluation of existing varieties from around the world. From this survey the variety Taichung Native I, which had been developed in Taiwan, was selected for distribution to other countries in the rice bowl area for evaluation.

Taichung Native I proved to be highly productive not only in the Philippines but also in India, Pakistan, and other rice bowl countries and has furnished the cutting edge in gaining recognition for the importance of agricultural technology not only among farmers but also by government leaders.

The IRRI rice breeding program has developed a number of new high yielding selections from crosses involving the tall growing Philippine variety "Peta" and short statured japonica or indica varieties from Taiwan and other countries in Southeast Asia. One of these, designated as IR-8, has high yielding ability, some resitance to the Tungro virus disease, and is short-strawed and nitrogen-responsive. IR-8 has produced six to ten metric tons per hectare in yield trials in rice bowl countries where average yields range from one to two tons. The short-statured, nitrogen-responsive rice varieties have been accorded the same enthusiastic reception in India, Pakistan, and other countries as have the Mexican wheats.

A matter of concern is, of course, the capability of the countries into which these new wheat and rice varieties are being introduced so rapidly to carry out the plant disease detection and breeding programs required to stay ahead of destructive disease and pest hazards.

Channels for the Transfer of New Technology

The effectiveness of adaptive research in furnishing the base for increased agricultural productivity has been demonstrated by the experience in wheat production in Mexico and is being demonstrated with wheat and rice production in Asia. The new technological inputs can be supplied expeditiously and at relatively low cost. Adapted food crop varieties and production practices can be produced for almost any agricultural area of the world within 3 to 5 years through well-organized applied research programs. This is about the time required to build a fertilizer plant so the rejection of research as too ponderous for today's pace of agricultural development is no longer valid.

Our experience in 15 years of U.S. foreign aid furnishes proof that new technology for agricultural improvement cannot be introduced on a haphazard "cut and try" basis or be treated as a condiment, to be sprinkled into a general mix of rural development measures. A well-ordered, systematic effort is required. Among the significant features which distinguish the Rockefeller Foundation program are:

(1) the emphasis on research to modify and adapt new technology to specific environments,

(2) the vesting of leadership in well-trained scientists who are given maximum autonomy in planning and conducting the research and development programs,

(3) continuity of leadership and of budgets, and

(4) the training of the full range of indigenous personnel, from technicians through the scientific competence required to furnish conceptual and directional leadership.

The procedures of the Rockefeller Foundation in improving food production technology in Mexico and other developing countries are

familiar to U.S. agriculturists who have participated in our federal-state cooperative research programs. They follow the pattern initiated in the U.S. on a national basis in the 1920's when the cooperative projects were established for improvement of corn, wheat, and other cereal grains. The cooperative wheat improvement program, with regional coordinating leadership for interdisciplinary research to improve the various market classes of wheat, and with centralized services for milling and baking and other tests, is a prime example of an integrated, problem-oriented research effort that is national in scope.

Serious consideration is now being given to the development of similar systems for agricultural science and technology on an international basis. At the meeting of the Development Assistance Committee of the Organization for Economic Cooperation and Development, held in Paris in April 1967, the U.S. delegation presented a proposal on "The Planning of Systems of Agricultural Research," which recommended the establishing of special research centers at the world or regional level, and the strengthening of national systems of science and technology, for expediting the development, adaptation and use of advanced technology for the benefit of the less developed nations. This proposal was received with positive interest by the members of the DAC which includes the European nations together with Australia, Japan, and Canada, essentially the "donor nations" who are contributing major support along with the U.S. for international economic development programs.

More precise proposals are now being developed with respect to specific crops or agricultural problem areas, and to possible locations for regional coordinating or leadership centers designed to provide

facilities for applied interdisciplinary research, to supply technical in-service training--including attention to extension methods, and to furnish a documentation and informational resource. A follow-up meeting of the DAC will be held in October to consider these more specific proposals.

Some existing centers or programs supply a base for expanded and integrated systems of agricultural science and technology. The International Maize and Wheat Improvement Center in Mexico is the major resource for new materials and practices that may be adapted to increase productivity of these crops in other developing countries. This center serves Latin America and consideration is now being given to establishing regional research and training centers to serve such areas as the Near East and Africa.

The International Rice Research Institute in the Philippines is the world's leading research, training and information center for rice improvement. Special cooperative projects initiated in Pakistan in 1966 and in India in 1967 are providing professional leadership from the IRRI for adaptive research and testing programs in those countries. The cooperation in Pakistan is financed primarily by the Ford Foundation while that in India is supported jointly by the Rockefeller Foundation and the Agency for International Development. The Agency for International Development also is collaborating in a program to accelerate the testing and use of the new high yielding varieties and production practices in the various rice growing areas of the Philippines.

The IRRI will serve the immediate needs of the smaller countries in the rice bowl area as well as guidance for adaptive research in India

and Pakistan. Consideration is being given to the development of special regional centers for rice improvement to serve the countries in Africa and Latin America.

The research program of the Agency for International Development is adding important strength to international systems of research for agricultural improvement. Since the initiation of a central research program in AID in fiscal year 1962, the Agency has obligated more than $38 million for research of which about 40% or approximately $15.3 million, has been devoted to 26 projects in agriculture and rural development. The projects related to production improvement are problem-oriented and are concerned primarily with adaptation of advances of U.S. technology. The AID research program is handled through contracts with other organizations since the Agency does not have an adequate in-house staff for planning and carrying out the research activities.

Most of the projects are regional in nature so facilitate the interchange of new knowledge and materials among countries within a given geographic area. As an example, since 1963 North Carolina State University has been conducting a project on analysis of the nutrient status of soils in Latin America. This project has guided the development of soil testing laboratories in a number of the Latin American countries and has fostered the exchange of information by agricultural scientists of those countries.

The Agricultural Research Service of the USDA is carrying out a project on the improvement of the major cereal crops in Africa, with special emphasis on corn and sorghum, and on the improvement of grain legume production in the Near East and South Asia areas.

An excellent example of problem-focused adaptive research is the application of the sterility method for control of the tsetse fly in Africa. This project, conducted by the Agricultural Research Service, is designed to adapt the techniques that have been so successful in the

The International Cereal Disease Nurseries of the USDA have been most useful in furnishing new germ plasm for crop improvement research and will continue to be a major factor in strengthening international systems of food production technology.

We have many elements of strength and extensive experience in cooperation in international agricultural science. The major need is for sustained and expanded budgetary support and for capable staffing of the research centers and projects to supply the stability of funding and leadership any research effort must have if it is to be productive.

Building Indigenous Research and Development Capabilities

The ultimate goal in our international cooperation is the establishment of strong indigenous institutions to serve the continuing needs of the individual nations. We can no more expect to perpetuate the exportation of new technology than we can expect to meet world food requirements by exporting wheat, rice and other commodities to the food deficit areas of the world.

National systems of institutionalized agricultural science, rooted in sound education programs and designed to supply a steady flow of useful information and materials, not only to farmers but also to industry, will be necessary for developing countries to meet their rapidly growing demands for food and other agricultural products. This is basic to any "self-help" in economic development.

A number of countries have made substantial progress in upgrading their agricultural research and education programs. India is a good example. When we think of India it is usually in terms of a primitive

agriculture increasingly unable to stave off serious food deficits. In the past decade, however, India has made excellent progress in strengthening its agricultural research and education institutions. The central government support for research is being directed increasingly to "all-India" coordinated, inter-disciplinary projects or schemes to improve production of the major crops including wheat, rice, sorghums, millets and maize. The leadership of the Indian Council for Agricultural Research has been transferred from the administrative service into the hands of qualified agricultural scientists.

The Graduate School at the Indian Agricultural Research Institute has modified its patterns of teaching and is directing attention of its students to significant inhibiting factors in Indian agriculture. With the guidance of the U.S. land-grant universities of Ohio State, Illinois, Missouri, and Tennessee, Kansas State, and Penn State, new agricultural universities are being established in selected Indian states. These institutions, together with the research and educational support from the central government, will furnish an outstanding institutional base for India's agricultural development in the future.

Mexico is also building a strong institutional structure for agricultural research and education, based on the trained Mexican scientists who have participated in the cooperative Rockefeller Foundation research and fellowship program. The national headquarters at Chapingo will have excellent facilities for research and education, with research stations in the various agricultural regions of the country supplying an effective network of institutions to serve total national needs. While the original support for the agricultural research program in Mexico was

furnished largely by the Rockefeller Foundation the more recent institutional development is being financed jointly by the Rockefeller and Ford Foundations, the Agency for International Development, and the Inter-American Development Bank. The government of Mexico is, of course, furnishing the major support for the new facilities. This pattern of joint funding by private and public organizations, including the international banks, is most effective in meeting the costs of institutional development.

Substantial progress is being made by other countries in Latin America in strengthening their research and educational systems, including Colombia, Peru, and Chile.

There are a number of countries which, on the basis of their rate of growth and increase in gross national product, are expected to graduate in the next few years from U.S. foreign aid support. Taiwan and Libya are among the countries which no longer receive technical assistance or economic aid and Korea, Turkey, and Iran are expected to receive diminished support in the future as their economies improve.

It is important for us to weigh carefully the capability of such countries to carry on their own programs in science and technology as the base for continued agricultural and general economic growth. As a result of our past policies to limit the training of agriculturists from developing countries largely to in-service tours in U.S. institutions many of these countries are well endowed with technicians but are lacking in scientists and engineers capable of furnishing intellectual and planning leadership. In most cases, also, they have not established

the effective institutional base for agricultural research, education, and extension that is essential as a "self-help" component.

Science and Technology in the U.S. Foreign Aid Program

There has not been adequate support for science and technology in our foreign aid program and our technical assistance efforts have reflected this lack of effective backstopping. In 1960, on the initiative of Dr. George Kistiakowsky, the President's Science Advisor, a special panel of the Office of Science and Technology was appointed to review the need for a research component in U.S. foreign aid. The panel recommended the initiation of research by the Agency for International Development and suggested that support eventually might well be required at the level of $100 million annually to attack problems in agriculture, health, education, industrial development, and other areas.

Support for research in AID has fluctuated from a budget of $7.5 million in fiscal year 1962, to $3.2 million in 1963, $6 million in 1964, and to a high of $12 million in 1965. The funds were reduced by the Agency to $9 million in 1966 and to $8 million this past fiscal year.

The limited staff support for planning and management of the technical cooperation and research component of AID was further curtailed in the reorganization of February 10, 1967 and on the basis of the evidence over a period of five years that the Agency was not prepared to furnish either the financial or staff support for a meaningful program of research, the Office of Technical Cooperation and Research was abolished during the past fiscal year.

There is still a deep seated conviction among those who furnished the initiative and guidance for establishing a research program within AID that such a component is essential if we are to have a sound program in cooperative technical assistance and in general economic development. The supporting judgment of the President's Science Advisory Committee Panel on the World Food Supply has already been mentioned.

The National Advisory Commission on Food and Fiber, in its report to the President on July 16 stated that "the main weapon in the War on Hunger must be technical and research assistance in agricultural development and population control." The Commission recommended that a special government corporation or "new, semiautonomous institute" be established to coordinate and administer foreign technical assistance and to furnish long-term organization and funding stability.

A focal point for technical cooperation and research activities at the federal level is essential to furnish planning and coordinating leadership for these activities in our complex relationships abroad. Further consideration must be given to the organizational pattern of such a science and technology program, including the alternatives of:

(1) a continuing effort to build an effective base within the foreign aid program,

(2) the centering of leadership responsibility in the U.S. Department of Agriculture and other federal departments and agencies, or

(3) a semiautonomous center for education and research in foreign aid, as proposed by Dr. John W. Gardner and his special task force in the report of April 1964 on "AID and the Universities."

In any pattern of organization in the future it will be essential to have continuing full cooperation from the land-grant univerities, the federal agencies concerned with agricultural development programs, and from private industry. The past efforts of private foundations and our federal foreign aid research program have built elements of strength but we must now give greater joint attention to the assembling of an effective U.S. organizational base for international science and technology. We cannot expect to make significant progress in meeting the world food and population problems if this is not done.

REFERENCES

1. Cummings, Ralph W. "Wheat Production Prospects in India." Wheat Quality Conference Report, Crop Quality Council. Minneapolis, Minn. February 1967.

2. Gardner, John W. "AID and the Universities." Report to the Administrator of the Agency for International Development. Washington, D.C. April 1964.

3. Paddock, William and Paul. Famine 1975. Little, Brown and Co. Boston, Mass. 1967.

4. "Progress Report: Toward the Conquest of Hunger, 1965-66." The Rockefeller Foundation. New York, N.Y.

5. "Report of the National Advisory Commission on Food and Fiber." The White House. July 1967.

6. Siverd, Charles D. "Proceedings of the Nineteenth Annual Midwest Fertilizer Conference." Chicago, Ill. February 15-17, 1967.

7. Stakman, E.C., Richard Bradfield and Paul Mangelsdorf. Campaigns Against Hunger. Harvard University Press. Cambridge, Mass. 1967.

8. "The World Food Problem." Report of the President's Science Advisory Committee Panel on the World Food Supply. The White House. May 1967.