A WORKING DRAFT of the

COMMENCEMENT ADDRESS BY NORMAN E. BORLAUG

OHIO STATE UNIVERSITY

MARCH 20, 1981

DR. ENARSON, MEMBERS OF THE FACULTY, MEMBERS OF THE GRADUATING CLASS, PARENTS AND LADIES AND GENTLEMEN:

I have participated in many commencement exercises in Universities of the Developing Nations, during the 37 years I have lived and worked abroad. Only rarely, however, have I been privileged to participate in such events in the U.S.A., where I was fortunate to have been born and educated.

I congratulate all of you who are graduating today. For most of you, the degree you receive marks the culmination and termination of your formal education. But I urge you to continue to broaden your knowledge through reading, personal exchanges and discussions with others and through travel; for education is a never ending process. Much of what you have learned, as facts or truths during the past four years, will with further study and research be found to have been only partial truths. To discontinue the process of informal self-education soon leads to mental stagnation, early fossilization of intellect and frustration.

Tomorrow you embark on or commence your life's work. Many of you who still have not found suitable employment, I am certain, are concerned. With the economy in disarray, as it is today, and with the scarcity of employment opportunities, some of you may be wondering whether the years of struggle and study were worthwhile. With time - come what may - I doubt any of you will ever regret having taken the time and made the effort to attain a higher education. On ocassions such as this commencement, I reflect on my grandfather's advise given during the depth of the economic depression of the 1930's urging me to work and struggle for a university education. My grandfather, a largely self educated man of modest farm background, insisted that a good education was the best protection against the ebb-tide and flood-tide of social economic and political upheaval. He was correct! During the past three decades I have spent living and working in dozens of different developing countries, involving governments of all different political ideologies, I have seen many people lose their land, jobs and savings. Those individuals with a good education - combined

with good self discipline, motivation and creativity - have adjusted and recovered, whereas others, poorly prepared, have not been able to make the adjustment.

In the few minutes I have available I will address my remarks, primarily, to the members of the graduating class and their parents. Some of the points of view I will emphasize, bear on how I perceive certain current problems and issues in the U.S.A. as contrasted with how these same issues are viewed in developing nations, and several may sound strange to you. This divergence in point of view arises, because of difference in the order of importance that is given to these problems (e.g. health, education, employment, industrialization, energy and mobility, food and agriculture, recreation, environment, endangered species and population) - in different countries; and in turn they reflect contrasting stages of social, economic and political evolution. What currently may be a non-essential luxury in an affluent nation is a scarcely available necessity in a developing nation and vice versa.

Often when I read the American press, or hear the news on radio or television I become concerned about our complacency and arrogance. We seem to take for granted the high standard of living we enjoy today, while failing, too often, to comprehend the assistance of 18 to 20 generations of our American forefathers who contributed so much toward what we enjoy today. It is true our nation was blessed with a great wealth of natural resources, with a vast area of potentially productive land in a wide range of mostly favorable climates and with extensive deposits of virtually all of the major mineral and non-mineral non-renewable resources. But it took the collective,well directed effort of many 10's of millions of people - visionary government leaders, educators, farmers, laborers, craftsmen, scientists, engineers, merchants, entrepreneurs, etc. - over most of four centuries (including the colonial period) to convert this potential wealth into reality, thereby resulting in the highest standard of living the world has ever experienced. But if complacency prevails, and the recent loss of productivity and creativity continue, our economy and standard of living will retrogress. There is no time for preening and gloating over past accomplishments. Moreover, it would appear to me, that to continue to steer a course demanding more and more pay for less and less work while production falls is self destructive and will make the U.S.A. a second class nation.

There are already storm warnings of rough seas ahead that threaten the quiet waters through which the U.S.A. economic ship of state has sailed, ever

forward for the past 200 years toward "the American dream land of milk and honey" with its assured and automatic ever increasing standard of living; prior to World War II the U.S.A. was self sufficient in almost all non-renewable minerals, including petroleum. Currently we import from 80-100% of the following minerals that are vital to our industries: strontium (100%), columbium (100%), mica (sheet 99%), cobalt (98%), manganese (98%), titanium (97%), chromium (91%), tantalium (88%), aluminum (ore and metal 88%), asbastos (87%), the platinum group (86%), tin (86%), flourine (86%), mercury (82%) and bismuth (81%). Moreover, there is another group of 12 important minerals that we import in quantities ranging from 40 to 80% of our industrial needs. This group includes: nickel (73%), gold (69%), silver (68%), selenium (63%), zinc (61%), tungsten (60%), potassium (58%), cadmium (53%), antimony (46%), tellurium (47%), barium (40%), vanadium (40%) and petroleum (40%).

The quantities and costs of imports is growing rapidly and worsening our unbalance of payments and adding to inflationary pressures. If we were denied the importation of several of these essential basic minerals, as we were of petroleum during the 1973-74 OPEC embargo what would happen to our industrial production and to employment? What, as an indirect effect would happen to social unrest? A tragic national calamity would likely develop. Eight years have passed since the OPEC petroleum embargo and we have done virtually nothing to change our life style or to shift to other sources of energy which could reduce our unbalance of payments, our vulnerability to future political blackmail and to the possibilities of another petroleum embargo. We continue to worship the family automobile - the golden calf of the twentieth century - while neglecting the improvement of public transport systems. Apparently the majority of the public believes the limitations on petroleum and gasoline availability is a hoax cooked up jointly by the OPEC nations and the voracious American oil companies. We continue to act like the proverbial ostrich who puts his head in the sand until the storm passes. Oh were it so simple ! Until very recently, the American automobile industry has obliviously continued to produce huge gasoline guzzling cars, irrespective of the high and rapidly increasing prices of gasoline. They and the automobile owners jointly appear to be determined to make Will Rogers 1930s prediction come true: "that the United States will be the first that will go broke (because of the automobile) but none the less will drive to the (county) poor farm in a late model car". If Will Rogers only knew that many of the late model cars taking

Americans to the poor farm today are of Japanese manufacture, he would certainly turn over in his grave.

The American economy continues to be vulnerable not only on the energy front but also to embargoes on a number of vital minerals as well. None the less we continue to bikker and squabble and play games to satisfy the whims or calm the fears of a host of, often elitist, and narrow special interest groups, many of them members of one or more environmentalist group. Little thought appears to be given by them to the effect of their activities on the economy, inflation and standard of living of the general public.

Recreation appears to be more important than the health of the economy. While one group lobbies and succeeds in getting a hundred million acres of public lands set aside as recreational wilderness areas to be used only for back-packing, thereby precluding its use either for the production of forest products, or minerals, another group lobbies against the construction of dams to generate hydro-electric power because it conflicts with the interests of canoeists. A third group lobbies against the expanded use of coal as a substitute energy source for petroleum because of sulfur dioxide and acid rain. A fourth group led by an emotional movie star and a rabid consumer advocate who probably know no more than I do, which is virtually nothing, about the benefits versus risks of atomic fission as a source of power carry the day with regulatory agencies in Washington against the opinions of recogn'zed authorities on atomic power such as Drs. Glenn Seobory and Edward Teller. Such lobbyist groups have virtually brought a halt to the development of additional atomic power plants during the past year. But the record of university administrators and qualified research scientists is not lilly white on many of these complex vital issues. They too often remain mute rather than stand up in defense of basic truths apparently because of fear of reduced legislative support. And while the development of alternate sources of power are blocked, energy costs continue to skyrocket being propelled in a large part by the rampant social virus - inflation that destroys the purchasing power of the dollar. Dr. John McKetta, a petroleum expert at the University of Texas, predicts that if the current 15% inflation rate continues crude oil prices will soar to $100 a barrel by 1995. What will this do to our economy and to our democracy?

We have all read about the rampant inflation that destroyed the Weimarer Republic of pre-World War II and paved the way for Hitler's rise to power and the catastrophies that followed. During my more than a third of a century

abroad I have witnessed the demise of democracy in many countries, victims in most cases, either directly or indirectly, of unchecked rampant inflation which tears apart the social fabric of a nation and pits one sector against another. This usually has resulted in the take over by a military dictatorship of either the right or left. Three cases in Latin America can be used to illustrate the sequence of events and perhaps serve to warn other nations of this danger.

Uruguay in the 1930's and early 1940's was known as the Little Switzerland of the Americas because of its model stable democratic form of government. It had virtually no mineral resources and little industry. Its economy consequently was almost entirely based upon the production and export of agricultural products, primarily wheat, beef, mutton and wool.

By the late 1930's its government had enacted legislation to provide a social program, which included unemployment compensation, early retirement and a medical insurance program, that was far superior to any such social benefit program then in use in the U.S.A. The program was financed by funds largely derived from taxes on the export of agricultural products to Europe. As agricultural prices and income from agricultural exports increased during the war years the benefits under the plan were expanded greatly. When the international prices for agricultural commodities declined dramatically during the post war years it posed a serious problem for continued financing of the social plan. The money supply was greatly expanded as a temporary "solution" which soon resulted in a rampant inflation. By the late 1960's social unrest was widespread and urban terrorists and guerrillas threatened to overthrow the elected government. As the social chaos worsened, the reigns of government were taken over by a rightist military coup - and Uruguay lost its democracy.

The sequence of events that led to the loss of the democratic form of government in Chile are very similar. Chile during the 1930's and the early 1940's enacted an ambitious program of social benefits similar to that of Uruguay, which was also largely financed by an export tax on one commodity - copper. When the world copper price collapsed in the late 1940's and early 1950 the social program was financed by expanding the money supply, which soon gave rise to spiraling inflation. Costs of living soared and social unrest worsened. Allende, the Communist Party candidate, was elected president, perhaps, at least in part, because he campaigned on the promise to bring inflation and cost of living under control. He failed in his attempt to do so, and instead

inflation skyrocketed to more than 500% during his last year in power. Contrary to American newspaper reports, by the time his administration was toppled by a rightist military coup d'etat his popular support had withered because of his government's inability to cope with inflation. The case of the best wheat scientist in Chile, illustrates the plight of victims of inflation. He informed me in 1977, that after 35 years of government service, even though his salary had increased 38 million times above that of his beginning salary in 1942, he was having difficulty providing for his family. If this was the condition of a top scientist imagine the far greater plight of the low income laborers.

Argentina, too, one of the richest countries in Latin America, has had continuous unbalanced budgets and serious inflation over the past 40 years. Military governments rather than democratically elected governments have held power over most of this long period. During the past five years its inflation has ranged from 150 to 400% per year.

It is the same story everywhere, irrespective of ideology and kind of government - eg. Uruguay, Chile, Argentina, Poland - when rampant inflation flourishes personal freedom and democracy wither.

Apparently during the last U.S. election the American public reacted and elected Reagan, at least in part because of his promise to balance the budget and reduce inflation. However, in recent weeks it appears that congress may not yet be willing to bite the bullet and try to bring inflation under control because now many of their special interest bulls are being gored.

When one reflects on the many foibles of democracy,one marvels at its ability to survive. Perhaps its ability to endure is best explained by Winston Churchill's famous quotation: "It is the worst form of government, except for (those) other forms of government that have been tried from time to time".

The American people have maintained vigor through adversity many times in the past. But the continuing drain on their life resources have thinned their blood and weakened their resistance to a point where a transfusion may not succeed in renewing the patent unless the many senseless abuses are soon mitigated.

Over the past decade we have heard repeated emotional debates lamenting the fact the world is running short of fossil fuel energy. So far we have seen little positive action to cope with the pending problem. It is true that the demand for petroleum and gas is already outpacing production and the situation

will become critical within the next two or three decades. Although the world's deposits of coal, according to some authorities, are adequate to meet the energy and power demands of the world for the next century and beyond, doomsayers and environmentalists of various stripes have confused the public and congress with their diatribes and up to now have successfully delayed the rapid expansion of the use of this fuel. One group of prophets predict increased use of fossil fuels will increase the carbon dioxide content of the atmosphere which will restrict the escape of infrared heat from the surface of the earth thereby producing a warming green-house like effect which will melt the polar icecaps and flood many of the coastal cities of the world. At the same time, another fraternity of doomsayers, also affiliated with certain meteorologists-climatologists, are predicting the planet earth is entering another ice age. Meanwhile, a third group of doomsayers - the anti-atomic energy apostiles are apparently convinced that the use of atomic power plants will increase the incidence of deaths from cancer as a consequence of increased exposure to irradiation. So we can thank the collective effect of the fraternity of doomsayers for effectively delaying the development of substitute energy sources to replace petroleum.

But the world has an even more critical menacing and complex energy problem than that of fossil fuels, namely the food energy problem. It is a continuing sneaky problem that stealthily grows in magnitude because of the relentless increasing pressures exerted by the growth of the human population monster. On this front there are no acceptable substitutes for food energy.

Food is the first basic necessity for all of us. And yet in a country as privileged as the U.S.A., which has long been a large producer and is currently the largest exporter of food in the world, it is very easy to take for granted how important food production and equatible distribution is to social and political stability. The famine in the African Sahel countries a few years ago led to the fall of the governments in power which were replaced by revolutionary governments of one kind or another. When stomachs go empty, patience wears out and anger flares. If the world is ever to achieve social, economic and political stability, I assure you, it won't be done on empty stomachs.

Most people fail to realize that there can be no long delay in meeting the growing demands for more food. If the world failed to meet the growth in demand for two or at the most three crop years many countries would be plunged into social and political chaos. Yet in urban areas of the affluent

industrialized nations food is taken for granted by most of the population. Most urbanities everywhere, and those of the U.S.A. are no exception, seem to believe that food comes from the supermarket, and that it is easily produced and should always be cheap. They seem to have no concept of the magnitude of the food production needs nor of the capital investments, managerial skills, work, and risks - of adverse weather, of crop losses caused by diseases and pests and unpredictable economic variables - that are involved in producing the food for the present world population of 4.4 billion people, which continues to increase annually at the rate of 75 million.

Fortunately, food energy is á renewable resource and in this way very different than fossil fuels. All of the worlds food energy, either directly or indirectly, results from plant chlorophyll capturing or harvesting the suns energy and photochemically converting it into carbohydrates, proteins and fats, some of which are used for the plants own metabolism and some of which is stored in its tissues, including seeds, nuts, tubers and fruits, etc which also serve as food for man and feed for animals.

In 1975 when world population was 4.0 billion, the total food harvest reached 3.3 billion metric tons, incorrected for moisture. Of this total approximately 98% of the tonnage was produced on the land and only 2% was harvested from the oceans and inland waters. Unfortunately there seems to be a feeling among many that when the world can no longer produce the food it needs on the land we will be able to harvest vast quantities from the still largely untopped oceans, which represents 71% of the surface of the earth. The present evidence does not support such a hypothesis. After World War II the world catch of fish, shrimp and mulluok rose dramatically with improved equipment for harvesting. It leveled off at about 70 million tons. Some authorities claim that several of the preferred food species are already being overfished. Other less preferred species that are not currently harvested might, in the future, be fished and thereby double or even triple the present catch. Even were this to happen it would none the less still only represent a small percentage of the annual world food needs. The available data now available indicate that we should not be deceived by the vastness of the oceans as a boundless source of human food. In effect there must be large biological deserts in the oceans as far as useful food species are concerned.

Our food supply consists of many plant and animal products. Cereal grains as a group, which includes wheat, rice, maize, barley, sorghum, oats, rye and millets constitute the largest and most important single group of foods.

They play a unique role as foods for they possess a desirable combination of characteristics including low moisture content which makes them easy to store and ship, combined with high caloric and protein content. Cereals collectively represent 41% of the tonnage, about 1.36 billion tons, and are grown on approximately 50% of the arable land area of the world. They directly provide about 52% of the calories to the human diet worldwide and approximately 62% of the calories to diets in the developing countries. Moreover, they supply nearly 50% of the total protein intake. Indirectly cereals also contribute greatly to both human protein and calorie intake, for approximately 35-40% of the world tonnage of cereals is fed to livestock to produce meat, milk, cheese and eggs. The emphasis I have placed on the importance of cereal grains in no way is meant to denigrate the importance of potatoes, yams, cassava, sugar, beans, peas, cowpeas, chuckpeas, lentils, soybeans, peanuts and other oil seeds, a vast array of fruits, vegetables and nuts, as well as meat, milk, cheese and eggs all of which are important in the total food supply.

Whenever we discuss food requirements by necessity we must always at the same time raise the question - food for how many? Unless we can, in the future, produce and more equitably distribute adequate food (the first basic necessity) to feed the growing world population there can be no social, economic or political stability among our ever more interdependent group of nations.

There is still heated debate about the date man or "near man" appeared on the planet Earth. For our purposes let us assume that he has been roaming the Earth for at least 3 million years.

About 12,000 years ago man discovered agriculture and about the same time learned to domesticate animals. World population then is estimated to have been approximately 15 million people. With a stable food supply population growth rates accelerated. It doubled four times to arrive at a total of about 250 million by the time of Christ. Since that time the first doubling - to 500 million - occurred by 1650. The second doubling required only 200 years to arrive at a population of one billion by 1850. That was about the time of the discovery of the nature and cause of infectious diseases and the dawn of modern medicine and the resulting improved hygiene--which soon began to reduce the death rate. The third doubling - to two billion - occurred in 1930, only 80 years after the second doubling. Soon thereafter sulfa drugs, antibiotics and improved vaccines were discovered, which again reduced death rates spectacularly. World population doubled again - to four billion people - in 1975. This doubling took only 45 years and represented an increase of 256 fold - or eight doublings - since the discovery of agriculture.

Now let us briefly glance at developments on the food production front.

At least since the beginning of written history, and undoubtedly countless times before, there have been many crises in food production leading to famines which were triggered by droughts, plant diseases, insect plagues, including

hordes of locusts, grasshoppers and crickets. Each crisis was precipitated when the human population was approaching the carrying capacity of the land then under cultivation with the production methods then available.

After each crisis more land was opened to cultivation - for then land with good agricultural potential was plentiful - to produce more food to feed the growing population. But population growth in those early times was slow because man had little control over the environment, his food supply or his diseases. Over the past 350 years most of the best land, from the standpoint of good agricultural potential, has been opened to production in the U.S.A. The same is true of most other countries in the Americas, in Asia, Africa and Europe. The question remains how much more good land can the USA and other countries of the World successfully open to agricultural production, to meet growing demands for food and fiber, in the next 40, 60 or 80 years (during which time the next doubling of world population will occur)? It is true that the development of large irrigation and drainage schemes such as in the Indus-Ganges-Brahmaputra basin in South Asia, the Mekong in Southeast Asia, the Niger basin in Africa and the Amazon andParance basins in South America could bring large areas of land under higher production. But this will require enormous capital investments which are beyond the capabilities of individual nations. Moreover, international agreements and international financing will be required to begin to develop the potential of these projects, and the gestation period between planning. construction and complete implementation will be long - three to four decades at best. There are also vast tracts of land with good precipitation that gradually can be opened to agriculture in Sudan. Similarly, Brazil has vast tracts of laterotic, leached highly acid soils in areas with precipitation of 1,000-1,600 mm. Twenty-five years ago these areas, known as the "campo cerrado", variously estimated to constitute an area of 60-100 million hectares, were regarded as having little

potential value for agriculture. But with the introduction of new technology - including liming and the proper use of fertilizer and improved varieties - this area in the past 15 years has become the second largest producer of soybeans in the world. Under the economic stimulus of world wide shortage of edible oil and meal Brazilian soybean production increased from 350,000 metric tons in 1965, to 10 million tons in 1975 and to 12 million tons in 1979 - truly a revolution in soybean production. With the development of proper technology - especially the development of improved disease resistant agricultural and tree crop varieties with better adaptation to these difficult soil conditions - it is very possible that this area will become important producers of maize, sorghum, sugar cane (for gasohol), cassava, improved pastures, and possibly also triticale and or wheat and Eucalyptus spp and Pinus spp for wood, pulp, lumber and methanol products.

The grass savannahs of Central Africa, in many ways similar to the "campo cerrado"of Brazil--but with the added curses of African sleeping sickness and nagana (the corresponding disease of domestic livestock), malaria and yellow fever--and the savannah of Colombia and Venezuela, also offer opportunities for large increases in livestock production and cultivation if weeds, crop and animal diseases, insects - including vectors that transmit serious human, animal and plant diseases, can be controlled. It is my contention also that whether we like it or not, much of the area now covered by tropical rain forests in the Amazon basin, in Central Africa and in Indonesia will be opened to agriculture during the next four decades in one way or another either by the slash and burn migratory agriculture of the past or by intensively well managed plantation tree crop agriculture that can have minimal negative impact on these so-called fragile environments. The pioneering Daniel Ludwig's Forest Plantation Project on the Jari river, a tributary of the Amazon, has already demonstrated that pulp, paper and lumber can be successfully produced without destroying the eco-

system while at the same time providing a far better standard of living for all employees - including the laborers - than they would ever achieve under a slash and burn migratory agriculture.

The same opportunity exists for the successful development of plantations of African Oil Palm, Brazilian rubber tree (Havea brasiliensia), coffees, Cacoa and a number of nut tree species. How fast these potentialities become realities will depend upon how soon agressive research programs are established and maintained to develop appropriate technology on which sound plantation management can be based, and, moreover, will depend on whether governments will establish economic and political policies that will permit the establishment of plantations and the adoption of the technology as it becomes available. I sincerely hope that jointly the Brazilian politicians, the international bands of neo-environmentalists and God give Mr. Ludwig another 10 years of creative active life so that he can remove all doubts about the soundness of the plantation tree crop approach for use of part of the land in the humid rain forest tropics.

Even though I have gone into considerable detail to show that there is a large area of land that can be brought under production in the medium time frame--40-60 years--the potential of this production will not contribute greatly in the next two to three decades. Therefore in the short term--the next 10-30 years--a different approach, namely, increasing crop yields, on the land currently under cultivation throughout the world, must provide most of the needed increase in food production to stay ahead of population growth while the population monster is being tamed.

The soundness of this approach is abundantly evident from an examination of the revolution in crop yields that has taken place since 1940 in American agriculture, and made it the envy of all other nations, and especially of the socialist countries.

But the revolution in crop yields and production did not happen overnight. Its ground work was laid in 1862 when President Lincoln within a period of a few weeks signed bills that established the Land Grant Colleges, which have subsequently become great universities, the Bureau of Agriculture which was to subsequently evolve into the U. S. Department of Agriculture and the Homestead Act, which provided land to many landless immigrants and other Americans who had interest in becoming farmers. Each of these laws have contributed greatly to the improvement of agriculture. Subsequently in 1884 under the Hatch Act the Agricultural Experiment Stations were established, mostly in conjunction with and to strengthen the research efforts of the Land Grant Colleges and Universities. In 1914 the final key organization of the triumverate (education, research and extension) - the Federal Extension Service was established and charged with the responsibility of extending the new technologies to farmers and ranchers as they become available from research.

But the increase in food production in the USA for the first more than 300 years--from the early Colonial period up until post World War II--followed the traditional pattern of other countries by increasing the area under cultivation as the markets for more food and fiber justified. During the period from about 1830 up until 1930 the greatest progress made toward increasing production was through the development of and widespread adoption of improved farm machinery, until the first decade of the twentieth century horse powered and subsequently steam and petroleum powered. Improvements in farm machinery contributed to increased production in two ways, namely, by 1) increasing the area that could be cultivated by a family and 2) by modestly increasing yields per acre through better seed bed preparation, better conservation and utilization of moisture and better control of weeds.

But the really dramatic increases in yield per acre had a long gestation period. In the last half of the nineteenth century early American researchers drew heavily upon the research experience in soil fertility and crop rotations, etc. that was being developed by Leibig in Germany, Laws and Gilbert in England and Bassingault in France. The pioneer work of Pasteur, DuBarry, Koch, etc. strongly influenced our early U.S. research efforts in plant pathology, veterinary medicine, and entomology. But it was not until the last decade of the nineteenth century and the first two decades of the twentieth century that most of the pieces of the American production technology jig-saw puzzle had been developed by our early researchers in the fields of soil science and agronomy, plant breeding, plant pathology, entomology, animal breeding and nutrition, and veterinary medicine. Through a stroke of bad luck in timing most of the technology lay dormant and unused for 15 years paralyzed by lack of markets and agricultural overproduction, during the economic depression of the 1930's. Then quickly with the demand for more food to support our European, African and Asian allies during World War II, and immediately following the war, when their agriculture was in disarray, the economic parts of the American production jig-saw feel into place, the demand for more food on the market which stimulated more production. Yields and production began to rise. But the most spectacular increase took place during the 1950's and 1960's with the rapid expansion of the infracture for production and distribution of inputs such as fertilizer, weedkillers, pesticides. The private sector played a major role in the development, introduction, distribution of these inputs, as well as the development of better equipment for use in their application. Then in the greatest revolution in crop yields that the world had ever seen, the short 30 year period from 1938-40 compared to 1971-73 yields per acre in bushels rose spectacularly as follows:

Corn 28.4 to 92.3; Wheat 14.2 to 32.8; Soybeans 19.2 to 27.7; Sorghum 13.0 to 57.7; Barley 23.0 to 43.2; Cotton 0.5 to 1.0 (bale); Beans 8.9 to 12.4 (100 lb.s); Potatoes 75.0 to 231.0 (100 lbs.); and Peanuts 7.5 to 21.9 (100 lbs.)

Although yield per acre of these same crops has continued to increase during the past decade, it is at a much slower rate than during the 1950's and 1960's, and this trend is likely to continue, for it will become more and more difficult to obtain further increases as the maximum biological yield limits are approached. This being the case, if the world is to avoid repeated famines in the next three decades it will be absolutely essential for third-world developing nations, where yields per acre are still very low, to dramatically increase their per acre yields of all basic crops.

The first foreign technical assistance program designed to assist a developing nation to improve its agriculture was the Cooperative Mexican Government-Rockefeller Foundation Agricultural Program, which was established in 1943. The objectives of the program were three-fold: 1) to train a corps of young Mexican agricultural students and turn the responsibility for the leadership of the program over to trained Mexican personnel as soon as possible, 2) to establish a network of agricultural experiment stations and 3) to launch agressive interdiscipline research programs to develop technology capable of increasing the yields of corn, wheat and beans to put this technology to work on farms as soon as reliable research results were developed. I joined Dr. J. G. Harrar , the director of the program, who subsequently became president of the Rockefeller Foundation, and Dr. E. J. Wellhausen, who was then in charge of corn research, about a year after the program was begun, and have worked ever since in foreign agricultural development in many Latin American, Asian and African nations.

Mexico's greatest obstacle to improvement of its agriculture when the program was initiated, was shortage of trained scientists. To this day this continues to be the greatest obstacle to improving the agriculture in developing countries.

Experience, first in Mexico and subsequently confirmed elsewhere, has shown it takes from 15 to 20 years to select and train a sufficient number of top-flight scientists to take over management and effectively operate a national research and extension program.

It took twelve years (1944-56) to develop the new technology to make Mexico self sufficient in wheat production. It remained self sufficient in wheat production until 1976 when it again began to be overwhelmed by population growth, eventhough per acre yields continued to increase. The national average wheat yields have increased from 11 bushels per acre in 1944 to 52.5 bushels in 1980. During years with favorable weather the best farmers produce 105-110 bushels per acre compared to 30 bushels in 1944.

During the 1960's it became apparent that much of the wheat production technology--including the high yielding semi-dwarf varieties--that were developed in Mexico, could be used successfully in many other parts of the world when proper adjustments were made in agronomic practices to fit local soil and climatic conditions.

We have had the satisfaction of seeing wheat production in both India and Pakistan triple and that of Turkey double since 1967, attributable in a large part to research done in Mexico during the 1950's and early 1960's and "transplanted," after extensive testing, to these countries in the period of 1962 to 1966. Other countries which have also made notable progress in increasing wheat production,