SYMPOSIUM ON SCIENCE AND FOREIGN POLICY

# THE GREEN REVOLUTION

## PROCEEDINGS

BEFORE THE

## SUBCOMMITTEE ON NATIONAL SECURITY POLICY AND SCIENTIFIC DEVELOPMENTS

OF THE

## COMMITTEE ON FOREIGN AFFAIRS

## HOUSE OF REPRESENTATIVES

NINETY-FIRST CONGRESS

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# INTRODUCTION

On December 5, 1969, the House Foreign Affairs Subcommittee on National Security Policy and Scientific Developments, in accord with its concern for scientific and technological advances affecting foreign policy, held a 1-day symposium/hearing devoted to the Green Revolution.

The Green Revolution, of course, refers to the effects which have resulted from the introduction of the recently developed high-yield cereal varieties into the less-developed countries of Asia, Africa, and Latin America.

The objectives of the subcommittee in holding the symposium/hearing were several:

First, we hoped to acquaint Members of Congress more fully with the Green Revolution phenomenon, from the development of the new seeds by American-sponsored agri-scientists to their social, political, cultural, and economic impact in poor countries.

Second, we wished to bring together in one place at one time for discussions and an interchange of ideas a group of outstanding specialists in various aspects of the multifaceted subject, in order to reach an integrated understanding of the Green Revolution.

Third, we wished to help draw some conclusions about the best methods of maximizing and extending the benefits of the Green Revolution, while ameliorating possible adverse effects. This would include providing a forum for recommendations for future U.S. policy on agricultural development abroad, particularly as embodied in the foreign aid program.

Finally, we sought to produce a subcommittee publication on the Green Revolution which would be both current and comprehensive. Therefore, to the papers and comments of the participants have been added several appendixes which include other relevant documents and materials.

Although the format under which the day-long program was conducted departed from the usual pattern of subcommittee proceedings, the symposium/hearing moved along smoothly, largely because of fine cooperation and deep interest on the part of the participants.

All of them men with national reputations and busy schedules, they devoted themselves to their roles in the program with deep seriousness and high intelligence.

The subcommittee also benefited from the presence of a considerable number of invited observers, representing departments and agencies of government, colleges, and universities, business and industry, religious groups, foreign embassies, and other interested organizations.

Through questions asked from the floor and statements submitted for the record (see appendix I), the observers contributed to the value of

the symposium and of this subsequent subcommittee document on the Green Revolution.

The dominant theme which emerged from the symposium was that, although much has been done through genetic engineering of seeds to increase agricultural production, the task of feeding the world's hungry millions has only just begun. Ahead are a multitude of other difficult problems, including troublesome effects arising from this technological innovation.

Although there was no easy optimism about the future, participants expressed general confidence that difficulties are surmountable if they are approached with firm purpose and constant will by leaders and peoples of the world. In other words, mankind can be fed, if we men choose to do so.

To that transcendent effort, therefore, this volume is dedicated.

CLEMENT J. ZABLOCKI,
*Chairman, Subcommittee on National Security Policy and Scientific Developments.*

JANUARY 7, 1970.

# SYMPOSIUM ON SCIENCE AND FOREIGN POLICY: THE GREEN REVOLUTION

FRIDAY, DECEMBER 5, 1969

HOUSE OF REPRESENTATIVES,
COMMITTEE ON FOREIGN AFFAIRS,
SUBCOMMITTEE ON NATIONAL SECURITY POLICY
AND SCIENTIFIC DEVELOPMENTS,
*Washington, D.C.*

The subcommittee met, pursuant to call, at 9:30 a.m. in room 2172, Rayburn House Office Building, Hon. Clement J. Zablocki (chairman of the subcommittee) presiding.

## OPENING REMARKS OF CHAIRMAN ZABLOCKI

Mr. ZABLOCKI. Mr. Secretary, gentlemen, my colleagues, friends: It is indeed a pleasure and a privilege for me to chair today's symposium/hearing on science and foreign policy, sponsored by the House Foreign Affairs Subcommittee on National Security Policy and Scientific Developments.

The subject which has brought us together here has been called, in a shorthand phrase—"The Green Revolution."

While the use of a slogan like "The Green Revolution" is perhaps unscientific in tone, the term expresses graphically the dramatic changes which are taking place in the less developed countries because of the introduction of the high-yield cereal varieties—the so-called miracle grains.

These changes, I believe, are inadequately understood by the American public generally and, to some extent, not fully understood here in Congress.

Although more than one-quarter of all development loan funds during the past several years have been spent on advanced agricultural technology, there is little awareness of the full import of what has been happening as a result.

The revolution in food production which has been spurred by the recent technological advances in agriculture are certain to have ramifications for our Nation's foreign policies. It is not too early to make an assessment of its effects.

That is perhaps the most important reason for the convening of this symposium.

## OBJECTIVES OF SYMPOSIUM/HEARING

We in Congress are interested in being more fully acquainted with this phenomenon called the Green Revolution. Through our support

for foreign assistance, we have been an integral part of what has been called the greatest success story of foreign aid since the Marshall plan.

If we are to convey an understanding of this achievement to our constituents, we must be aware of the full scope of the Green Revolution—from the development of the cereal varieties by American agriscientists, to the economic, social, political, and cultural effects which have resulted from introduction of these grains in the less developed countries.

The subcommittee's purposes here today, however, go beyond being instructed.

We also have attempted to bring together in one place for discussions and an interchange of ideas a group of leading experts from a number of disciplines in order to create an integrated appreciation of the Green Revolution.

In that effort, the subcommittee has been particularly fortunate. We have been able to gain the cooperation of an outstanding group of Americans to deliver papers and to serve as panelists.

We are honored as well by the presence here this morning of the Secretary of Agriculture, the Honorable Clifford Hardin, who will deliver the keynote address.

Moreover, there are here today, sitting in the audience as observers, many individuals who might well be sitting here on the dias as participants. We look forward to their making a contribution to the dialog.

We invite your comments and questions.

In addition, everyone who is in attendance as observers here today is invited to submit brief written comments on matters covered in the symposium.

Those statements will be published in the printed record of the proceedings. They should be in the hands of the subcommittee no later than 2 weeks from today—December 19—in order that we can include your remarks in the record.

By including such statements, together with the record of today's proceedings and other relevant materials, the subcommittee hopes to compile as comprehensive a volume as possible on the Green Revolution.

Moreover, we hope that today's session will result in some consensus on means of maximizing the benefits of the Green Revolution, while ameliorating possible adverse effects. This may include recommendations for new departures in U.S. programs and policies.

### FORMAT OF THE SYMPOSIUM/HEARING

In carrying out its objectives today, the subcommittee has chosen a format somewhat different than the usual hearing procedure.

Today there will be three sessions. Each will begin with a paper being presented by one of our distinguished participants. Following the paper, a panel of three discussants will make statements.

Following the panel's commentaries, there will be a question period. First, I will call upon my congressional colleagues for questions to be put either to the author of the paper, or to one of the panelists. Then questions will be in order from any of the participants.

If time remains when those questions have been exhausted, we will open the session to questions from the floor.

INTRODUCTION OF SECRETARY HARDIN

At this time it is my pleasure to introduce our keynote speaker for the day, the Honorable Clifford M. Hardin.

Born on an Indiana farm, Dr. Hardin received a Ph. D. in agricultural economics from Purdue in 1941 and subsequently taught at the University of Wisconsin.

In 1944 he moved to Michigan State University where he ultimately served as director of the MSU experimental station and held the position of dean of the school of agriculture.

In 1954 Dr. Hardin became chancellor of the University of Nebraska. While serving in that capacity, he helped establish the new Attaturk University in Turkey and program for agriculture in Colombia.

He was president of the Association of State Universities and Land Grant Colleges in 1960 and has served as chairman of the American Council on Education's Committee on Institutional Grants Abroad.

He was sworn in as Secretary of Agriculture on January 21, 1969.

Although his present responsibilities require primary attention to domestic agricultural problems—of which there are many—he has had a longstanding interest in international agricultural development.

May I present the Secretary of Agriculture, the Honorable Clifford M. Hardin. Dr. Hardin.

## STATEMENT OF HON. CLIFFORD M. HARDIN, SECRETARY OF AGRICULTURE

Secretary HARDIN. Mr. Chairman, Congressman Ross Adair, distinguished members of the panel, and members of the audience:

I feel almost I should start with an apology this morning. I am going to speak from a manuscript which is the second time I have done this since I have been in Washington.

I don't know whether this proves anything or not. I guess not, except that I will get through more quickly, Mr. Chairman.

I am sure you will agree, also, that it is difficult to be asked to keynote a symposium that has such an impressive roster of panelists and speakers.

You have assembled here individuals with wide and varied experiences with the Green Revolution, the term now generally applied to the development and use of new grain varieties and the application of modern techniques to subsistence agriculture.

Your program and the fund of knowledge which these men will bring to bear on each of the topics assure a stimulating and informative day.

With that in mind, it occurred to me that my most useful contribution to a gathering such as this would be to attempt to offer some perspective from which to view the Green Revolution that will be discussed in detail by our panelists and speakers.

In other words, I am not going to try to cover the whole thing in my presentation.

## THREE PRECEPTS FOR THE GREEN REVOLUTION

It seems to me that we should approach the Green Revolution with three precepts in mind:

First, we should understand what it is not, as well as understanding what it is.

Second, we should understand that there is no magic in technology unless it is applied.

And third, we must remember that projections of the world food problem are just that—projections; forecasts of what might happen tomorrow based on our information available today, and that is subject to change.

### I. "MAGNIFICENT ACHIEVEMENT"

First, there is no question about what the world agricultural revolution is: It is a magnificent achievement and one that offers new hope to developing nations.

Several factors are involved in this revolution. Among these are growing awareness in many developing countries of the importance of agricultural improvement, a willingness to devote more of the national resources—material and human—to it, and to recognize the importance of increasing the standard of living for producers of food.

In too many countries they are still following a cheap food policy for the people and preventing the farmers from participating fully in advancing standards of living.

This is not the way to get the job done.

The development of new high-yielding varieties of wheat and rice has had a dramatic impact and has created worldwide excitement and hope.

As I look over the group in the audience, I know most of them are well aware of the Rockefeller and Ford support for developing the dwarf wheats in Mexico that are being planted now in North Africa, the Middle East, and across South Asia.

Department of Agriculture economists estimate that these improved varieties cover about one-sixth of total wheat acreage in West and South Asia. They make an admittedly difficult estimate that these new varieties might add about 20 percent to the production in this area this year compared to what it would have been without them.

Two new tropical strains of rice, developed at the International Rice Research Institute, a combined Ford-Rockefeller Foundations venture in the Philippines, now cover about 7 percent of the riceland in South and Southeast Asia. It is roughly estimated that they might add as much as 9 percent to production in this area this year.

### II. "NO MAGIC IN TECHNOLOGY"

Figures like these are exciting, but they may lead to the erroneous conclusion that the Green Revolution as it exists today is a total and lasting solution to the hunger problem. It is not.

It is adding, as the figures show, to food supplies where there have been shortages. It is increasing incomes and enhancing life in some areas. But it does not contain within itself the capacty to make the large investment in such things as irrigation facilities, in internal net-

works for marketing and distribution, or to make the farm and consumer policies necessary to realize its potential.

This is what is implied in my second precept for viewing the Green Revolution: There is no magic in technology unless it is applied.

The progress to date indicates to me that we have the technology in hand or in sight to feed the world's population of 2000 A.D. better than they have ever been fed. But only if we put it in the right place, and use it correctly—and that means an effort of unprecedented magnitude by all nations, developed and developing.

It means a commitment from the developed countries to make the technology available.

It means a commitment—and a heavy one—from the developing countries to make the adjustments they must make to use it properly.

They must be prepared to invest the men, money, and materials that are needed to create the internal institutions—the schools, the programs, the trained personnel—without which the technology cannot be put to work.

Food that spoils because of lack of storage facilities does not help build healthy bodies; food that can't be distributed for lack of market facilities fills no stomachs beyond the farm; miracle varieties produce no miracles without the proper fertilization, water, and tillage.

These are some of the factors that must be faced if the Green Revolution is to fulfill its promise as a principal vehicle for reaching the ultimate goal—that of providing all people with a nutritious diet.

How many people and how much food will be available 10 years from now, or 20, or more, we don't know; we cannot know.

As all of us know, estimates, opinions, and forecasts of the size and scope of the world food problem have fluctuated—and widely. Concern over food shortages was expressed in the late 1940's, had diminished by the early 1950's, and then turned to alarm in 1966 on the heels of 2 drought years in India and two crop failures in 3 years in the Soviet Union.

In the face of this, the Department of Agriculture and other agencies urged expanded production. Our farmers responded, and at the same time record grain crops were produced in the Soviet Union, India, Canada, Australia, Western Europe, and South Africa.

By 1968, the world supply of food exceeded effective demand and export markets were drying up. That is a situation that exists still today.

So we have had world feast and world famine projected alternately four times over the past 20 years or so—twice in the past 3 years.

### III. PROJECTIONS SUBJECT TO CHANGE

We must, of course, assume something with respect to the future in order to make plans for the future. But there is a strong tendency, I think, to project from present conditions without accounting enough for variables. Weather, for instance, can cause as much as 25 percent fluctuation in agricultural production, and obscure other changes.

We must remember that we have had generally good weather worldwide the past 2 years, and that conditions of market surplus will not necessarily extend to the future if we experience average weather in the years immediately ahead.

Additionally, the history of new varieties has generally been that in field use they eventually become susceptible to local disease and insects, reducing yields until countermeasures are taken.

We haven't had this with the new crop varieties to any degree. I suppose it is possible that they will escape it, but probably not. They will be susceptible to attacks and new resistance types will have to be developed, which will be.

But it does mean a slowing down temporarily, though not a cessation of the progress.

Future consumption is difficult to pin down. Last April, the Pakistan people were visiting the Department, working on their Public Law 480 contract for this year. They told us that they would need no wheat, no Public Law 480 wheat, this year.

They said it with great pride, that they might even have a bit of a surplus this year as a result of the new crops. They were back in September, just a little over a month ago, pleading for 1 million tons of wheat, after 4 months. They described a near famine condition in East Pakistan. They explained that their production forecasts were generally holding up, but they had underestimated market supplies, or the reaction of people, people in the producing areas, were eating more with their improved income and so on, and feeding more of their locally grown feed to their locally grown livestock, and perhaps eating more of it, though this didn't come out.

EFFECTS ON U.S. FARMER

Anyway, it didn't come to the market and they couldn't move it to East Pakistan. So this means, I think, that, as we look ahead, there is a temptation for many to look at this as competition to the U.S. farmer, and to point out that we must revise our export plans for the future.

I should like to say that I don't think it means this at all. There is a possibility that it could temporarily reduce demand for U.S. products.

On the other hand, it could work the other way. I think you could build a logical case that as levels of living rise, and diets improve, and particularly the animal parts of the diet, it could be that with their increased affluence in some of these developing countries, they will actually import more rather than less.

This is more apt to be true in the long run, perhaps, than in the short run.

Then there is another hazard in making these forecasts, and particularly the rosy ones, because forecasts of surplus food lead the public and some others to think that the job is all done.

Most of us here know that it is not, and far from it. But if people generally believe it is done, then it is hard to get the support, it is hard to get the task accomplished.

There is an immense task ahead, one that will require the best efforts of the affluent as well as the poor, because there is no question that the developing countries will need all the help the developed countries can provide.

The important thing about the Green Revolution, despite the "ifs" and "buts" that I have raised with you this morning in this preliminary statement, is that agricultural development, where it is

needed, is off dead center. It is moving, and in this movement there is hope.

Mr. ZABLOCKI. Thank you, Mr. Secretary. We certainly want to express our deep appreciation for your coming here and giving this fine keynote address. We know of your tight schedule. You have given us some of your valuable time this morning.

We realize you have other commitments, Mr. Secretary, and I understand you would desire to leave now. Whenever you wish to, feel free to do so.

Secretary HARDIN. Secretary Freeman will be here and he will be be glad to take over, I am sure.

Mr. FREEMAN. Thank you for the delegation.

## SESSION I: THE GREEN REVOLUTION AS AN HISTORICAL PHENOMENON: WHAT HAS HAPPENED, HOW AND WHY

Mr. ZABLOCKI. In welcoming both participants and observers here, I certainly should have pointed out how grateful we are that so many of you from your busy walks of life have come here today. I know that this program will be very enlightening and fruitful to all of us.

In my introduction, I said that there would be a priority of questions in which the Members of Congress would have the first opportunity.

We operate under the 5-minute rule, I might say, for Members of Congress in hearings.

Then we will entertain questions from the panelists and then, of course, questions from the observers. Let me just amend that a bit. If there is a pointed question that an observer wants to develop, please do not hesitate to attract the attention of the Chair.

We wouldn't, however, want anyone to take the trend of discussion off the track. Otherwise, we welcome questions from anybody in the room at any time. We hope to be able to keep some sense of order, however.

At this time, I would like to call upon my colleague, Gov. Vernon Thomson, to introduce the panel.

### INTRODUCTION OF DR. MYERS

Mr. THOMSON. Thank you, Mr. Chairman.

Ladies and gentlemen, our program this morning indicates that the next paper will be presented by Dr. George Harrar, president of the Rockefeller Foundation, a distinguished professor of botany and plant pathology and noted agricultural specialist and administrator.

Yesterday, we were notified that Dr. Harrar had come down with the flu and is feeling miserable. He is ill and consequently will not be with us. We are, however, very fortunate to have with us Dr. Will M. Myers, who is vice president of the Rockefeller Foundation.

His official title is vice president in charge of agriculture, medical, and natural science program for the foundation. Dr. Myers will now address himself to the subject, "The Green Revolution as an historical phenomenon, what has happened, how and why."

Dr. Myers.

## STATEMENT OF DR. WILL M. MYERS, VICE PRESIDENT IN CHARGE OF AGRICULTURE, MEDICAL, AND NATURAL SCIENCE PROGRAMS, THE ROCKEFELLER FOUNDATION, ON BEHALF OF J. GEORGE HARRAR, PRESIDENT, THE ROCKEFELLER FOUNDATION, NEW YORK, N.Y.

Mr. MYERS. Congressman Thomson, Mr. Chairman, members of the panel, ladies and gentlemen. Dr. Harrar is, indeed, very sorry that he was unable to be here today. He has been anticipating for some time the pleasure of participating in this extremely important symposium.

When he talked with me yesterday morning to advise that he really would not be able to come, he asked that I express his regrets to you. He did want to come, but his doctor was very firm in insisting that he remain home in bed.

He has prepared a paper, which you either have or will have. I think it would be unwise for me to attempt to read Dr. Harrar's excellent paper. He advised me that he would not himself read it, since it would already be available for you to read. Instead, he said he would, and I shall, therefore, in order to emphasize them, speak about particular points that Dr. Harrar has made, and to elaborate on some of them.

### 1967–68 HISTORIC YEAR IN HUNGER FIGHT

The year 1967–68 may go down in history as a major turning point in man's continuing struggle against hunger. The Green Revolution which we are discussing today became a recognized phenomenon in that year. In that year, the Republic of the Philippines became, for the first time in recent history, self-sufficient in rice. India's 1967–68 food harvest was 12 to 15 percent greater than the best previous harvest they had ever had. West Pakistan produced enough wheat and almost enough rice for its own needs during that year. Kenya developed a surplus of corn.

We have estimates that in South Asia, largely in wheat and rice, and largely in Pakistan and India, approximately 9 million tons of food crops were produced in addition to what would have been produced under normal circumstances in that year. The value of this additional crop was, at world market price, about $1 billion.

This phenomenon—the Green Revolution—has opened a new era. Man now can dare to hope for a future without hunger. National leaders in the developing countries can now view their agriculture as a resource, not as a liability. Rural people can begin to participate in the market economy. Rural resources can be generated for improving education, health, transportation, and other services. Markets for products of industrialized nations can be opened up. And there are many other advances made possible as a result of the Green Revolution.

Coming as it did after a period of despair, when many eminent authorities had concluded that the collision between soaring population and limitations on food supplies was unavoidable, the Green Revolution brought new hopes to the hearts of man, new courage to struggle harder to win the war on hunger.

## FORCES IN SHAPING THE GREEN REVOLUTION

As pointed out in Dr. Harrar's paper, the Green Revolution sprang from a coalescence of many efforts and many advances. But the thing that finally made the difference, that triggered the revolution, was the use by many farmers in the developing countries of vastly superior technologies of production in wheat, rice, and maize and, to a lesser extent, in the sorghums, millets, and potatoes.

The key factors in these packages of superior production technologies were the improved varieties of wheat, rice, and maize and the other crops that had been deliberately engineered by the plant breeders to take maximum advantage of sunlight, water, fertilizer, good management, and other practices that were used with them. With this combination of varieties and superior practices, the farmer now had the capability of producing two, three, or even more times per acre the amount that he could produce with his indigenous varieties and the traditional practices he had been using.

This is not to suggest that the improved technologies were solely responsible for the Green Revolution. Dr. Harrar pointed out there are many other forces that have been developing and gathering momentum during the quarter of a century of efforts to stimulate agricultural improvement in the developing countries.

These include, among many other things, the following:

(1) The training of large numbers of scientists, educators, extension specialists, and other agricultural specialists, through training programs both in the developed countries and in the developing countries themselves.

(2) The development of agricultural institutions—colleges and universities, experiment stations, extension services, co-ops, and so forth—that were required for the national and local agricultural programs. These institutions had been built or strengthened in many of the developing countries through efforts by a large number of bilateral and multinational agencies.

(3) The emergence of an enlightened political leadership that recognized the contributions and potentialities of agriculture and that was willing to adopt policies and to allocate resources for the development of that agriculture.

(4) The existence of economic incentives for the farmers to produce more; prices that were higher, generated either by scarcity of food or by government guarantees of minimum prices, and input subsidies.

(5) The development of an agricultural industry to supply improved seed, fertilizer, and other agricultural chemicals, machinery, and other requirements to the farmers so they could put into practice on their farms the improved production technologies now available.

And there were many others. But the thing that made the difference, I repeat, was the availability of a vastly superior technology, especially the improved varieties that could respond with greatly increased yields to the other components of the technological package.

## ORIGINS OF THE IMPROVED CEREAL VARIETIES

As is the case with all great events, the Green Revolution did not just happen. Each of the components or forces that came together so dramatically in 1967–68 had been developing for many years. In

his paper, Dr. Harrar has traced the origin of the improved varieties which, as he has pointed out, were the key to the package of production practices which, in turn, was the key to the generation of the revolution that became so visible in that year.

One might, with wheat, in reference to the development of these varieties, go back to Gregor Mendel in the middle of the last century or to the wheat breeders of the late 19th and early 20th century, William Farrar of Australia, Engledom of England, the Howards of India, the Saunders of Canada, and many other pioneers, including a Japanese scientist whose name is unknown to me today. In rice there were also many pioneering plant breeders, Japanese, Chinese, Indian, and other nations and a few Americans. In maize one might start with G. H. Shull, E. M. East, D. F. Jones, F. D. Richey, H. K. Hayes, and others.

But, quite appropriately, Dr. Harrar begins his wheat story with Mexico, where he, in 1943, began the cooperative program between the Rockefeller Foundation and the Government of Mexico which was to do so much to generate the Green Revolution. Joining him almost at the beginning was Norman Borlaug whose lifetime devotion to better wheat has culminated in the development of the so-called Mexican wheat varieties.

These varieties have short, stiff straw, which was derived genetically from varieties developed by the Japanese plant breeder, whom I mentioned previously. It is interesting to recall that these varieties were seen in production and experimental plots in Japan by Dr. S. C. Salmon, then wheat specialist in the USDA, who went to Japan in the early days of SCAP to be head of the Agricultural Research Branch of the Agricultural Division.

He sent seed of these varieties back to the United States where they were used in wheat breeding programs at Washington State University and the U.S. Department of Agriculture. At an early date, the varieties were sent to Mexico, where Dr. Borlaug began to use them as parents in the development of the dramatically superior new dwarf wheat varieties which have come to be known as the Mexican wheats.

These varieties are now revolutionizing wheat production in Mexico, the Middle East and North Africa, and South and East Asia, and are having an important impact almost everywhere in the world where wheat is grown as an important crop.

### NATURE OF IMPROVED RICE VARIETIES

The first of the improved rice varieties for the great rice bowl of South and Southeast Asia came from Taiwan and, especially, from the International Rice Research Institute at Los Banos in the Philippines.

These varieties, too, have short, stiff straw so that they can produce much higher yields without lodging. They have stiff, erect leaves that maintain a maximum exposure to the sunlight in these areas of the tropics where often the intensity of light is a limiting factor in total crop yields. They are insensitive to the length of day; that is, their flowering and maturity is not controlled by changes in length of day versus night. Therefore, they can be planted at any time during the year and produce a crop in approximately the same number of days.

They mature in about two-thirds of the time of the tall, late, indigenous varieties of the tropics. As a result, three crops can be produced in a single year if water and other facilities are available. Therefore, the total productive potentialities per acre of land through the rice-growing tropics has been magnified dramatically.

### EASIEST PART ACCOMPLISHED SO FAR

Dr. Harrar emphasizes, correctly, that what we have accomplished so far is miniscule compared with the total needs. Secretary Hardin made this point to us in his opening remarks. We must continue to recognize this very important point. If we relax our efforts now, man's dream of freedom from hunger will never be realized. What we have accomplished so far in the Green Revolution is the easiest part. Vastly greater efforts will be required to sustain it in the areas where it is now occurring, and to extend it to the vaster areas of the developing world where it has not yet become a reality.

What the Green Revolution has done that is so important is to change attitudes, to provide hope, to point the way for even more rewarding advances in the future. We now are convinced we can win the struggle against hunger, at least through the next few decades, hopefully until we have been successful in coping with the problem of growing population.

The developing world is nearing the takeoff stage, so far as its agriculture is concerned. What is needed now are relatively massive efforts to push it forward. These will include assistance from the richer nations through such agencies as our U.S. Agency for International Development; assistance from the international agencies—FAO and the UNDP, and the international banks; from the private agencies, including the philanthropic foundations; from business interests in the developing world, and, most critical of all, massive efforts on the part of the people and the governments of the developing countries themselves. If they do not exert such efforts, none of the efforts from the outside will have much success.

With sufficient and collaborative efforts among all of these, man can, I repeat, hope to attain his dream of freedom from hunger. But the task is so big that it cannot be done by a few. It requires all of us working together. The time is now, and the time is short. If we fail, if, for example, the richer nations should abandon or lessen their efforts now because of other pressing problems, the opportunity may be lost, never to be regained.

We will sink once more into a sea of despair to wait for famine and chaos to overwhelm us.

### THREE REQUIREMENTS FOR FUTURE PROGRESS

To sustain and extend the Green Revolution, we need, as Dr. Harrar has pointed out, at least three things.

First, there must be effective programs to cope with what has been called the later generation problems. After increases in production are attained and production exceeds the needs in local areas, there are needs for facilities, institutions, and mechanisms for collecting, stor-

ing, processing, transporting, and marketing the excess production from areas in which it occurs to other areas of great need. Secretary Hardin pointed out, for example, the need for the West Pakistanis to move their surplus grains to East Pakistan where there still is a deficit.

There are additional second or later generation problems, which, I am sure, members of the panel will refer to, I shall not attempt, therefore, to discuss them now.

Second, we need massive research and training programs to develop new and even better technologies for the areas in which the present ones are superior and, in addition, for the much larger areas of the developing world where those which we now have are not especially adapted.

Third, further development and strengthening of national and local institutions in the developing countries are required to provide them with capabilities for their own sustained future development.

### MAGNITUDE OF RESEARCH NEEDS

I wish to refer particularly to the magnitude of the research needs. I believe there is no greater danger to the possibility of continuing with the advances in agricultural development which have begun than complacency which comes from the false assumption that we already have all of the technological developments required; that now all we have to do is to apply them. You may recall that Secretary Hardin said we have the technologies available or in sight. I would stress, and I am sure he would, the "in sight" part of his statement. We know that the necessary technologies can be developed; we do not yet have them.

I shall not take time to document in detail the magnitude of the research needs. I shall only summarize by saying that those of us who have been studying the needs believe there will be required, in the developing nations of the world, research efforts comparable in magnitude to those which provided the technologies that have undergirded agricultural abundance in the United States and the other developed countries. Furthermore these research efforts must be carried out in a much shortened time frame. We do not have a century, as we did in the United States, to develop the improved technologies required in the developing countries. Increases in agricultural production are needed now.

We have had substantial experience with intensive country programs, such as described by Dr. Harrar in his paper—the Mexican agricultural program, the Colombian agricultural program, and the Indian agricultural program of the Rockefeller Foundation, for example.

This experience tells us that, if there were sufficient time, we could through such country programs do the research to develop the technologies for increasing agricultural production, and conduct relevant training programs to produce the necessary numbers of agricultural specialists to staff the institutions of the developing countries. But there are not enough resources to develop simultaneously in all of the developing countries the required national institutions and programs for research and the training of people that will be necessary to sustain and extend the green revolution.

## SHORTAGE OF AGRI-SCIENTISTS AND SPECIALISTS

The human resource is most limiting. There are simply not enough scientists and other agricultural specialists to staff all of the institutions and programs needed in the developing countries on a country-by-country basis, even if the developed countries were prepared to provide all of their agricultural scientists and specialists to carry out the task and there is not enough time, I repeat, to continue to do the job of developing institutions, programs and people, country by country, seriatim.

What is needed, we believe, is a shortcut, a method which makes maximum use of the limited available supply of superior trained persons for the combined and closely related tasks of research, relevant training, and expediting the development of national and local institutions and capabilities in the developing world.

## INTERNATIONAL AGRICULTURAL RESEARCH INSTITUTES

Dr. Harrar refers to the international agricultural research institutes. These do, we believe, provide this kind of a short cut.

At each of them, a small group of highly competent scientists have been assembled to carry out intensive, multidisciplinary research on some of the major bottlenecks to increases in agricultural production, in specific crops, as is the case with rice, wheat, and maize, or in agricultural systems, as is the case, for example, with the agriculture of the humid tropics.

This same group of highly competent scientists provides relevant training to large numbers of people from the developing countries with which they are cooperating. They serve as a hub and a catalytic force for the development of a network of cooperative research and program activities involving increasing numbers of national institutions and national scientists in agricultural development programs related to the mission of the respective institutes.

There are now four such institutes. The first to be established was the International Rice Research Institute at Los Banos in the Philippines. The second was the International Center for Maize and Wheat Improvement in Mexico. These are both now fully developed and operating institutes. The other two are newer. Their programs and their staff are still being developed. One is the International Institute of Tropical Agriculture at Ibadan, Nigeria; the other is the International Center for Tropical Agriculture at Palmira, Colombia.

These institutes are autonomous international institutes. Each has its own international board of trustees to which the director and staff of the institute have full responsibility. They are not, as they are so often thought to be, simply dependencies of the Ford and Rockefeller Foundations. The two foundations took the lead in establishing the institutes. The two foundations continue to provide funds, at the request of the institutes, for part of their core operating expenses. The two foundations, again at the request of the institutes, also assist in professional and administrative matters. We are extremely proud of these institutes. But they are not our institutes. The institutes manage their own affairs and direct their own programs. They seek and obtain support from other sources.

That these institutes have provided an effective mechanism for helping generate, sustain, and extend the Green Revolution is evident, I believe, from the record.

I hardly need, even if time were available, to repeat the record. I shall cite just one figure. In the appendix of his paper, Dr. Harrar reports estimates that the increase in rice crop generated to date in South and Southeast Asia as a result of the varieties and improved technologies developed at the International Rice Research Institute had value of approximately $1½ billion.

### GREEN REVOLUTION: "NEW HOPE TO MAN"

In conclusion, I repeat first that the Green Revolution has brought new hope to man, a faith that we can, some day, be free from hunger in this world.

Second, the accomplishments to date are very modest compared with the task that remains. We are at a major turning point in agricultural development in the developing countries.

With the kind of massive efforts of which we are capable and which I hope we can bring to bear on this problem, we can push agricultural development in the developing countries to the point where it will have a self-sustaining momentum.

I end, then, by emphasizing, as Dr. Harrar did, that we can succeed. The question is whether we will. The more important question is, I think, Can we afford to fail?

Thank you.

(Dr. Harrar's paper follows:)

### THE GREEN REVOLUTION AS AN HISTORICAL PHENOMENON

(Paper prepared by J. George Harrar for Symposium on Science and Foreign Affairs, Subcommittee on National Security Policy and Scientific Developments, House Committee on Foreign Affairs—December 5, 1969)

The "Green Revolution" is the phrase now widely used to describe the dramatic changes that have been taking place in levels of food grain production in many of the developing nations. These changes have indeed been revolutionary in their effect on traditional agricultural patterns and production figures. The most important aspect of this phenomenon is the hope it offers of the possibility of gradually eliminating chronic hunger, malnutrition and the all-too-frequent famines from regions where they have long been ever-present threats to the society.

In general terms, the "Green Revolution" came about as the result of a growing understanding of the food needs of many of the disadvantaged nations and the determination to undertake positive action toward the conquest of hunger. For well-documented reasons, the economic development of many of the less advantaged countries has not kept up with that of some Western nations whose economies have forged ahead tremendously since the early 1940's. Bound by tradition and lacking the spectrum of resources and manpower necessary to maximize natural resources, these primarily agrarian countries remain largely in a state of chronic agricultural underpoduction. Before the development of systems of rapid communication and transportation, the plight of the less-developed areas was only vaguely understood and efforts to be helpful were small, scattered, and often not directed to the most critical concerns.

### MEETING WORLD FOOD NEEDS

During the past twenty-five years, various cooperative programs to increase food production have been initiated by United Nations agencies, national governments, and private organizations. These efforts were in no small degree a

response to a growing awareness of the need to help the less-developed nations to help themselves attain a more accelerated economic growth. They took many forms, some of them proving highly effective and others much less so. In view of the threats of hunger, malnutrition and starvation which perennially confront substantial parts of the world, agriculture, especially food production, was a natural and obviously focal point for many assistance programs. Numerous theories were advanced which were unfortunately not practical under the diverse conditions prevailing in these countries, and efforts to effect sudden breakthroughs in increasing world food supplies were equally disappointing. Ultimately, it was recognized by some that the problems of agricultural development in the less-advanced nations could not and would never be solved from the outside. Rather, they would have to be tackled in place, and many small battles would have to be won before there could be any expectation that the war on hunger could be satisfactorily concluded.

Early experience taught that no single technological application could contribute very much to the advance of agriculture. Rather, proper soil and water management, the use of agricultural chemicals including fertilizers, the control of pests and pathogens, and other technological inputs are insufficient unless economic accelerators such as credit, price support, adequate transportation and marketing systems, and the continuing improvement of agricultural education are all available and applied in coordinated fashion.

## THE "BIOLOGICAL PROBLEM"

Most important of all, however, is the fact that all of the technologies and economic inputs that can be brought to bear on the solution of food production problems will be unsuccessful unless the biological problem is solved. It has not always been clearly understood that in most of the less developed world, the varieties of food crops traditionally grown are of low maximum genetic potential. Through a long process of field selection, many have become adapted to unfavorable conditions and to that extent are "rustic" in their habits. Therefore, when they are subjected to the benefits of modern technology, materials and management techniques including the application of fertilizers, improvements in yield are limited by genetic factors and on occasions such increases are uneconomic in terms of the added costs. It is now clear that at the heart of the "Green Revolution" are these varieties of food plants that have been deliberately engineered to take maximum advantage of sunlight, water, fertilizers, and other inputs with the result that with adequate management they can be expected to produce several times the yields of the traditional unimproved varieties. These varieties have given the "Green Revolution" a sound economic base.

The recent dramatic progress in increasing the production of food grains on an international basis represents the progressive coalescence of many different efforts—large and small, individual and collective. It is fully recognized that enlightened political leadership, the investment of larger capital resources in the agricultural industry, growing numbers of trained scientists, technologists and teachers, the entry of business and industry into the agricultural sector, and many other factors have contributed to the successes thus far obtained. Nevertheless, it has been the confidence, based on visible evidence that the improved varieties can and will, under appropriate management, double, treble, and sometimes multiply six or seven times the customary yields, that has made the difference. Without this knowledge and assurance, based on experience, the "Green Revolution" would not have come into being.

Today, we recognize that what has been accomplished is minuscule in terms of the total need. It is massive, however, when we consider the extent to which it has changed attitudes and convinced statesmen, scientists, farmers, and business leaders that the status quo need not maintain. They have now accepted the fact that it is possible greatly to increase yields on the same lands which for centuries have been grossly underproductive.

Over the last quarter of a century, we have seen a variety of multilateral, bilateral and private efforts to improve food production in the developing nations. International agencies such as the Food and Agricultural Organization and the United Nations Development Program have conducted agricultural programs in many countries. United States foreign assistance programs, under the Agency for International Development and its predecessors, have rendered invaluable assistance and encouragement to the agricultural industries of the less-developed

nations. The United States land-grant colleges, under contract or other arrangements, have done much to raise the level of agricultural education and research activities overseas. United States business and industry have also brought their experience and resources to bear on the problems of strengthening agricultural economies. And, there are numerous other governmental and private programs which have made valuable contributions toward increasing world food supplies.

### ROCKEFELLER FOUNDATION WORK IN MEXICO

Given the obvious and continuing importance of all of the above efforts, individually and in concert, it might be appropriate to point out here that one of the very earliest steps—clearly germinal—toward reversing a national food-deficit position was the crop improvement program initiated in 1943 under a cooperative arrangement between the Government of Mexico and The Rockefeller Foundation. At that time, Mexico, in the face of a rapidly growing population, was obliged to purchase abroad substantial tonnages of bread grains. Working together, the Mexican Government and the Foundation identified the problems which limited production, established priorities, and jointly went to work to close the existing food gap.

The first and most obvious fact was that Mexico was deficient in the production of supplies of corn and wheat required as basic foods for the national population. Next it was essential to learn why these deficits existed and whether and how it might be expected that the gap between supply and demand could be closed. It was quickly determined that the varieties of wheat commonly used in Mexico were low in quality, poor yielders, and were highly susceptible to pests and pathogens, which regularly resulted in limited production, or on occasions brought about heavy crop losses. It was also determined that soil and water management as practiced was not conducive to maximum production, and that the use of fertilizers, pesticides and herbicides was minimal.

The first step, after arranging for appropriate land and equipment to be provided by the Mexican Government, was to bring together world collections of wheat and corn and put them into comparative yield tests in the various ecological areas in Mexico where these crops were widely cultivated. The superior strains were identified, selected, and multiplied and tested for productivity, adaptability and pest and disease resistance. As rapidly as information was obtained, breeding programs were begun in order to combine desired qualities from two or more varieties into a single hybrid. Ultimately, it was possible to produce new varieties which were obviously superior to those which they replaced. These provided visible evidence of the possibility for improvement and at the same time created a foundation of genetic materials on which to build for the future.

Genetic research and its adaptation was carried out in conjunction with research in plant pathology and entomology, weed control, seed bed preparation, cultivation practices, water utilization and storage problems. It was recognized that unless the approach to problems was through a systematic effort reflecting all recognized production problems, the desired goals could not be achieved.

### TWELVE YEARS TO DEVELOP NEW HIGH-YIELD VARIETIES

It required approximately twelve years to develop new varieties, to demonstrate their potentials for increased yields, to multiply and distribute seeds of the new varieties, and by demonstration bring about increased utilization of fertilizers and other agricultural chemicals within a management system designed for maximum yields. The food grain gap in Mexico was closed in the mid-1950's. Today, Mexico, with a population that has doubled since 1943, can and does satisfy its annual requirements for the production of wheat and corn. This was not the result of extending the areas planted to these crops, but rather the product of improved management, technology, the use of agricultural chemicals and fertilizers, the essential economic accelerators, and, most centrally, the development of high-yielding, well-adapted, disease- and pest-resistant varieties which enabled Mexico to treble annual yield figures.

The new wheat and corn varieties, during their several stages of development were tested widely, not only in Mexico but in many other countries where it was thought that they might be useful. In this way, an early multiplier

effect of the Mexican program was produced. Today, as a result of further experience and broad-scale international testing and refining, these now well-known Mexican wheats have proven their enormous value in countries thousands of miles distant including India, Pakistan, Turkey, Afghanistan, Tunisia, Kenya and even the United States, which now grow substantial acreages of wheats whose genetic composition was designed in Mexico.

Stimulated by the success in Mexico, somewhat similar ventures were undertaken in Colombia, Ecuador, Chile, and later in India, with outreach into many other countries. Each of these cooperative efforts gave added confirmation to the philosophy that well-reasoned, carefully planned, and scientifically based production projects could add significantly to food production levels and at the same time provide foundations for national agricultural development programs which were economically sound. In each country, major emphasis was placed upon the training of young scientists and others who would ultimately accept responsibilities for future leadership and action.

As efforts to improve wheat and corn on an international basis progressed, it became clearly evident that there was at least equal need for concentrated effort toward the improvement of rice production in the rice bowl of Asia and other rice-producing countries. In 1959, the Ford Foundation and The Rockefeller Foundation jointly embarked upon a project to establish the International Rice Research Institute in the Philippines. Today, this Institute is known world-wide, and its success in developing high-yielding, well-adapted rice varieties for many regions parallels the experience with the "miracle wheats" of Mexico. The Philippines now produce all the rice required for its national consumption and has a small export surplus. India, Pakistan, Indonesia and other Asian countries are taking increasing advantage of the "miracle rice" varieties, and they are now rapidly being introduced into rice-producing countries in Africa and the Western Hemisphere. As continuing research provides new methods, materials and further improved varieties, it can be expected that through well-conceived production programs, the world demand for rice can be satisfied within the foreseeable future.

Currently, other projects are under way dealing with sorghums, millets, potatoes, and grain legumes, and there is evidence that, based on experience it should be possible to make rapid strides toward improvements in these and other crops adding significantly to the world food budget. Coincidentally, work is being intensified on forage and pasture crops and the improvement of animal protein sources as an added dimension to the effort to increase world food production.

In all of these undertakings, efforts to add substantial tonnages to the world food grain budget have included comparable efforts to improve their nutritional quality. Progress in this direction illustrates that double benefits can accrue from the production and wide utilization of highly efficient crop varieties that are also richer in the compounds essential for human growth and energy.

The international institute concept is now widely accepted, and there are four such institutes now established or being established: the rice research institute in the Philippines, an international corn and wheat center in Mexico, and two tropical agriculture research institutes located in Nigeria and Columbia. As the programs of the last two develop and expand, it can be hoped and expected that the still underused tropics can begin rapidly to increase their contributions to world food supplies. It is interesting to note that the four institutes are now receiving support from national, bi-national, multi-national, and private sources.

## PROBLEMS OF THE GREEN REVOLUTION

It is fully recognized that all revolutions, even "green" ones, produce problems as well as benefits. And those who have had some responsibility for generating the "Green Revolution" are fully aware of the problems, both foreseen and unforeseen, that wil arise. But these problems have their principal origin not in any technological deficiencies in the programs, but rather in the fact that the radical and positive changes in yields place in imbalance other factors such as storage facilities, transportation and marketing systems, and the back-up economic machinery required to absorb satisfactorily in a short period of time the very large increases in tonnage of food grains. Neverthe-

less, problems created by abundance are preferable to those that arise from chronic underproduction. For the first time, there is now hope that world food supplies can be increased at rates which will ultimately lead to the conquest of hunger. With intelligent and vigorous leadership, a growing supply of manpower for scientific and technological responsibilities, in conjunction with increased understanding and support by the public sector and the farmers, the "Green Revolution" can grow into a major instrumentality for providing food and energy to millions now undernourished and inadequately fed.

The "Green Revolution" is a bold venture, fraught with risk. It has, however, already made major contributions to the well-being of millions of people in many countries and thus bears witness to the fact that careful evaluation, sound scientific and economic planning, and sustained effort can overcome the pathology of chronic under-production and gradually bring about rapidly increasing economic advance. A formula for success can be designed for any area that has available the new adapted plant varieties and the other inputs and accelerators that must be applied in logical fashion.

### BENEFITS OF THE GREEN REVOLUTION

At the same time that it has accelerated and intensified conventional agriculture, the "Green Revolution" has brought in its wake certain benefits that go far beyond simply increasing supplies of food, important as this may be. The income of many populations is moving up substantially, enabling them to purchase a greater variety of foods and also to buy the products of urban-based industry. They are now beginning to participate in an expanding market economy, thus contributing to the demand for the products and services from the urban sector. There is increasing evidence that the new wealth that is being generated in rural communities is contributing to local self-help efforts to improve education, health, transportation, and communication. Perhaps the most important change, however, is in the attitudes of rural people—the realization on their part that improvement of their condition really is possible and that they can provide a better life for their children.

The expansion of world economies through intensification of agriculture may also provide major and direct benefits to the developed nations, particularly in the expansion of cash markets for an ever broader range of industrial products.

The real challenges lie in the future. It is imperative that momentum not be lost and that the program be permitted to extend and expand as rapidly as possible, building on sound foundations Farmers almost everywhere have shown that they are ready and eager to do their part. They must, however, have the supporting services and materials essential to their task. Once they understand that improvements are possible and that these will bring concrete benefits to themselves and their families, they will accept change with enthusiasm. Nevertheless, agriculture is a fragile industry, always subject to the threat of losses from natural causes. Moreover, because it must seek continually to increase productivity on limited areas of arable land, agriculture must necessarily be a dynamic and ever-changing industry. The success of the "Green Revolution" will ultimately depend upon political leadership, financial support, economic planning, continuing support to agricultural research and education, the application of new technologies to increasing production, and the cooperation of the private sector.

### CONTRIBUTIONS OF FOREIGN ASSISTANCE PROGRAMS

I would like to conclude with a general remark or two concerning our foreign assistance programs. Many critics of foreign aid claim that little or nothing has been accomplished. In spite of the expenditure of vast amounts of money, they say, there has been much waste and little accomplishment either in material progress or in international understanding. There is no doubt that many of these large and far-flung programs have had a relatively low level of efficiency, especially during their early stages However, as experience is gained, priorities clearly defined and refinements made, visible progress begius to emerge. Today, there has been sufficient time and enough experience to demonstrate that many of the foreign-aid efforts have been exceptionally effective, and in their formal and informal interaction, these efforts can become synergistic. If the "Green Revolution" is to continue to advance the well-being of people in many lands,

this cooperative aid must be maintained and improved. From rather modest beginnings, the potentials of these programs have now been demonstrated. But future success depends on the degree to which there can be coordination of effort among all the agencies and organizations involved.

To illustrate some of the accomplishments of the "Green Revolution" there are appended some of the production figures which have now become available.

## APPENDIX

### MEXICO

In 1943, Mexico averaged wheat yields of 11.5 bushels per acre; half the wheat needed was imported. By 1964, 37 bushels per acre were the average and the country had wheat available for export. (1)

In 1944, Mexico imported 431,000 tons of wheat; today (1968) it exports 684,500 tons. In 1940, agricultural products were 19.7 percent of total imports. By 1967, the percentage had dropped to 11.4 percent. In 1940, agricultural exports were 18 percent of total exports. In 1967, they were 65.4 percent. All of this was done in a twenty-year period in which Mexico's population grew from 21 million to 37 million. (2)

In the early 1940's Mexico's average yields of wheat and corn were so low that any improvement, however slight, would automatically benefit the entire economy. The national average wheat yield was only 11.5 bushels per acre. Maize production averaged a pitifully low 8 bushels per acre (about one-fifth of the U.S. average in the Corn Belt). (3)

But by 1955, Mexico had closed its food gap in the production of both corn and wheat and had additional quantities of other food and related basic crops to meet national needs. By 1968, national average wheat yields exceeded 40 bushels an acre, or almost four times the 11.5 bushel average in 1943. Corn yields were double those of 25 years earlier. (The corn yield had been 8 bushels per acre; in 1968, it was about 16 bushels an acre.) Potato production was more than triple that of 1950. (3)

Dr. Theodore W. Schultz, economist at the University of Chicago, has estimated that, on the basis of a survey, Mexico is today drawing interest at the rate of 600 percent per year on all of the investment made jointly by the Government of Mexico and The Rockefeller Foundation in its corn and wheat improvement program.

### INDIA

In India, 18,000 tons of the Mexican wheats were imported in 1966. In the 1967–1968 season, 6 million acres were sown to dwarf wheats, 18 percent of the country's wheat acreages. This 18 percent produced much more than its proportionate share of the total crop for that season—an estimated 40 percent. (1)

In 1965, India began a program of high-yield varieties which set a goal of 32.5 million acres by 1970 to 1971; last year's crop season saw 18 million acres already planted, which contributed to the most successful year in recent Indian agricultural history (some 100 million tons of food grains, 11 million tons over the previous record year of 1964–1965.) (4)

Eighty-eight million acres of India are devoted to growing rice. (In 1968) 6 million acres have been planted to the new dwarf varieties. (5)

The new agricultural technology creates skyrocketing demands for agricultural supplies and equipment. For example, it is expected that farmers' use of fertilizer in India will rise more than six-fold in seven years—from 600,000 tons in 1963–1964 to 4 million tons in 1970–1971. (6)

The National average yield (wheat) in India in 1968 was about 1300 kilograms per hectare, or about 500 kilograms above the 800 kilogram average for the period 1962–1965. (3)

Within two years of its importation of the new dwarf varieties of wheat from Mexico, India had planted them on nearly 7 million acres, or 20 percent of the country's total wheat acreage. (3)

### PAKISTAN

Pakistan has planted approximately 2 million acreas of Mexican wheat for harvest this spring (1969) and hopes to plant up to 1 million acreas of International Rice Research Institute rich this year. (7)

In 1965, Pakistan bought 350 tons of the imported Mexican dwarf wheat for seed. These 350 tons were planted on 12,000 acres where they yielded a 50-fold

increase, four times the normal Pakistani yield. From the increase, 300,000 acres were planted, including 35,000 one-acre demonstration plots in 18,000 villages. In 1967, Pakistan imported 42,000 additional tons of Mexican dwarf wheats. These new varieties have helped end a 20-year food grain deficit. (1)

Pakistan has planted about 3 million acres, or about 30 percent of its total wheat acreage. (3)

Traditional food-importing nations like . . . Pakistan are becoming self-sufficient and have the prospect of becoming net food exporters. (4)

TURKEY

1967–1968-crop season in Turkey: 60,000 farmers participated, representing 19 of Turkey's 67 provinces. These farmers planted about 17,000 tons of Mexican-origin seed on 425,000 acres, throughout the coastal areas. An average yield in excess of . . . 52.1 bushels per acre was obtained, which contrasts to an average of not more than . . . 22.3 bushels per acre for native wheats in the same area.

The value of the increased production has been estimated at $23.6 million.

In January, 1967, AID helped the Turkish government purchase 50,000 tons of Mexican wheat seed for 1967 fall planting in the coastal areas. AID also provided the services of 12 United States county agents-farmers through a contract with Oregon State University.

The value of Turkey's increased production has been estimated at $23.6 million. The total costs to the Government and to the farmer for seed, fertilizer and other inputs were estimated at $18 million, giving a net profit of more than $5 million on the 1967–1968 program.

FAO and RF and the Mexican Government gave Turkish scientists training in Mexico on the new wheats.

In the 1965–1966 season, a farmer planted a few kilograms of two wheat varieties sent to him by AID technicians. This attracted the attention of neighboring farmers, and about 100 joined together to import 60 metric tons of one variety for the 1966–1967 crop. So, over a three-year period, the number of participating farmers in the coastal areas jumped from 1 to 102, and then to 50,000.

Eight hundred Turkish agricultural technicians were mobilized and trained to man the tremendous extension effort.

PHILIPPINES AND SOUTHEAST ASIA

In Southeast Asia, the Philippines already claims to have become self-sufficient; Malaysia predicts that she will be self-sufficient by 1971; Indonesia by 1973. (4)

Traditional food-importing nations like the Philippines . . . are becoming self-sufficient and have the prospect of becoming net food exporters. (4)

In the Philippines, the area planted to the "miracle rice" increased to around 400,000 acres by the end of last year, not including about 190,000 acres of two other improved varieties released at the same time. (7)

In the Philippines, for the 1968–1969 crop year, 12.3 percent of the total rice acreage was planted to IR–8, the most popular of the new rice varieties. (9)

ASIA IN GENERAL

It was recently estimated that the new rice varieties have now added approximately $1.5 billion to the Gross National Products of the "rice bowl" countries.

The total area planted to the new improved varieties has expanded at great speed in the last two years and is estimated to exceed 15 million acres this year over the whole region. It could expand further 30 million acres or more next year. (7)

The International Rice Research Institute developed new varieties of rice which reach yields of 5 to 7 tons per 2.47 acres instead of the 2 tons that had been the norm in Asia. (2)

The U.S. Department of Agriculture has revealed that in Asia alone the estimated acreage planted with the new high-yield varieties rose from 200 acres in 1954–1965 to 20 million in 1967–1968. (4)

The dwarf wheats have given a fertilizer response in . . . India and Pakistan of the order of 17 to 30 pounds of grain for each pound of nutrient furnished, as compared to 11 to 16 per pound of nutrient for the local unimproved kind. (1)

The farm sector now constitutes from one-third to one-half of most Asian economies. It is conceivable that the 2 percent rate of increase in food production prevailing during the early and mid-1960's could accelerate to 4–5 percent yearly over the next few years, provided markets can absorb the additional output. The additional purchasing power thus generated for both production and consumer goods will stimulate a more rapid rate of growth in the non-farm sector. The net effect should be a much more rapid rate of overall economic growth than would otherwise have prevailed. If the Asian agricultural revolution continues, it could well become the most significant world economic development since the economic rebirth of Europe following World War II. (10)

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9. Norman E. Borlaug, Ignacio Narvaez, et al., "A Green Revolution Yields a Golden Harvest," *Columbia Journal of World Business*, Vol. IV, No. 5, (September-October, 1969), pp. 9–19.
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Mr. THOMSON. The panel members that we will be privileged to hear are Mr. Orville L. Freeman, former Governor of the State of Minnesota and the former Secretary of Agriculture, and presently president of EDP International, Washington, D.C.; Mr. William S. Gaud, Executive Vice President, International Finance Corporation, Washington, D.C., and former Administrator of the Agency for International Development.

Mr. Fraser.

INTRODUCTION OF FORMER SECRETARY OF AGRICULTURE FREEMAN

Mr. FRASER. Thank you, Vernon.

I had sought to have the opportunity to say a word or two about these panel members. It sort of illustrates that all good things come in pairs. Just to the left of former Gov. Vernon Thomson is the former Governor of Minnesota, a man who I remember most fondly as having given me my first job when I got out of law school some 20 years ago.

It illustrates, I think, that lawyers, in his case, can amount to something.

Secretary Freeman was a graduate of the same law school, the University of Minnesota; a Purple Heart veteran of World War II; a three-term Governor of our State, and appointed Secretary of Agriculture by President Kennedy at age 42, the youngest man ever named to that post.

He served during the period in which the U.S. involvement in the development of agriculture overseas reached new and impressive heights.

After retiring from the Department of Agriculture, he became president of EDP Technology International, a firm which is organized to bring about better management through the use of computer and systems technology.

Might I say a word or two about the other panel members? Then they can all proceed.

INTRODUCTION OF MR. GAUD

The next panel member also shows that lawyers can amount to something. The former Director of AID began his career as a trial lawyer in New York City. Among his many distinguished achievements should be recorded that he was the first person to use the term "Green Revolution," a term which he employed in a speech to the Society of International Development in March 1968.

He was Assistant Administrator of AID for the Near East and Southeast Asia, beginning in 1961, Deputy Administratior of AID in 1964, and then, of course, Administrator in 1966.

Again, it was during his tenure in the AID Administration that AID came to place new emphasis, to put new resources, behind the development of agriculture in the developing world.

He resigned his post with AID in 1969 and is presently Executive Vice President of the International Finance Corporation.

INTRODUCTION OF DR. HARDIN

Finally, we have another pairing. One might say that when you have seen one Hardin you haven't seen them all. We have another Hardin with us. Lowell Hardin, who, in a sense, will represent the Ford Foundation.

I might express the personal thought that I wish some of our other colleagues would have been here today to learn more of the role that the foundations have played in making it possible for billions of people on this planet to look forward to survival rather than starvation.

Hopefully, it might influence their attitudes with respect to the role that foundations ought to be permitted to continue to play.

Lowell Hardin is an agricultural program officer for Latin America and the Caribbean for the Ford Foundation. He holds a doctorate in agricultural economics from Cornell University and taught at both Cornell and Purdue Universities.

For 12 years he was head of the Department of Agricultural Economics at Purdue, and he has been associated with the Ford Foundation's Latin America program since 1965.

He has coauthored the book "Farm Work Simplification," and is a Director of the Agricultural Development Council; a member of the panel on world food supply; on the President's Science Advisory Committee; and a member of the National Academy of Sciences Agricultural Board, and a cousin to Secretary Hardin.

Thank you, Governor Thomson.

## STATEMENT OF HON. ORVILLE L. FREEMAN, PRESIDENT, EDP INTERNATIONAL, WASHINGTON, D.C. (FORMER SECRETARY OF AGRICULTURE)

Mr. FREEMAN. Thank you very much, Governor Thomson.

Congressman Fraser, Chairman Zablocki, distinguished members of this committee, and ladies and gentlemen:

I think the scope, magnitude, and dimension, of the Green Revolution and its import has been sketched very skillfully and effectively by Secretary Hardin, by Dr. Harrar, and by Dr. Myers. By and large, the greatest benefit will come from the questions that all of you here will have from here on.

I will make two points quickly that might add a little dimension to what has already been presented.

### BREAKTHROUGHS IN PROTEIN POTENTIAL

First of all, no mention has been made so far of the whole area of nutrition, and the fact that great segments of the world exist under serious protein deficits; while at the same time, just as the Green Revolution makes possible enormously increased volumes of production, we also have had some significant technological breakthroughs in protein potential.

One breakthrough is, genetic, that is, breeding various strains of grain with significantly greater protein content. Strong beginnings have been made here.

The University of Purdue has come out with a new corn which is significantly higher in protein. It is being tested and applied in a number of places. There are still problems. Yields are lower than with other kinds of corn.

There are certain taste disadvantages as it currently stands. But the potential is enormous.

Humans in much of the less developed world eat corn directly. What a godsend it would be to have a higher protein content corn.

There are great genetic nutrition potentials that ought to be pushed hard. And that is true not only of corn but also rice and other grains. This is now being researched at Los Banos and other places.

In addition, the amino acids that make up the elements of protein, and necessary trace elements in food to make it nutritious have been synthesized artificially and can now be manufactured, at relatively low cost.

Lysine is the example we hear about most often. Currently and increasingly, wheat, for example, is being supplemented with lysine, by a relatively simple process.

Four pounds of lysine at a cost of $1 a pound increase the protein content of a ton of wheat by one-third. That is a very, very significant increase. A lot of experimentation is going on trying to get lysine and nutrition trace elements in various carriers such as salt, tea, trying to add them to the kind of things that people do ingest.

Some particularly striking work has been done on nutrition in India by Allen Berg, who worked for Bill Gaud in the AID programs.

## DEVELOPING HIGH NUTRITION FOODS

Another program that some of us collaborated on that I think is exciting is to try to develop new kinds of food or beverages, tailored to the eating habits of the people in need.

There is an old saying that you can take a horse to water but you can't make him drink.

By the same token, you can develop all kinds of nutritional foods but how do you get people to eat them?

It is said that people in India, during the great Bengal famine of 1942, starved to death because they were unwilling to eat wheat. They were rice eaters. To the extent we can tailor high protein foods to traditional eating habits, a great deal will be accomplished.

There is currently, and Bill Gaud can correct me on this AID sponsorship of a dozen or so American food development programs, primarily in Latin America, seeking to tailor enriched foods in traditional forms in both beverages and solid foods. Private American food corporations are working hard in this field.

This area of food technology, concentrating on nutrition and protein needs is a very, very important one. I testified before the Joint Economic Committee earlier this week and suggested we ought to have a food and nutrition policy in the United States where less developed countries are concerned.

## COUNTERPRODUCTIVE EFFECTS OF PUBLIC LAW 480

In the mid-1960's we realized that a substantial part of Public Law 480—Food for Peace—may have been counterproductive because it resulted in receiving countries neglecting their own agriculture. To paraphrase some conversations that I have had with ministers of agriculture in less developed countries, they would tell me, "I go to the finance minister and say, 'We have to have food. We are facing serious problems.' He would respond, 'I have a lot of problems but not enough money. If we have a problem, we can always get food from the United States.'"

Such conversations actually took place. So we developed what came to be known as the short tether policy. We said to LDC seeking Public Law 480 help, "We want to help you, we don't want anybody to go hungry. But if you are going to receive food from us under Public Law 480, we expect you to begin to make a major input into your own agriculture, and if you don't do that, we won't be very cooperative."

We developed a program between AID and Agriculture to carry out the short tether policy. And it worked. The budget for agriculture and the use of foreign exchange in the LDC moved up sharply.

## FOSTERING NUTRITION POLICIES IN THE LDC'S

I would like to see us extend the short tether policy to food and nutrition. I don't know a LDC in the world, that has a national nutrition policy. I don't know a less developed country that has sat down and tried to gather all the data as to their nutrition problem, what resources they have to attack malnutrition, and how should they go

about developing a national nutrition policy. Every LDC needs a policy on food and nutrition to supplement the program for agriculture that over the years most of them have developed.

It is shameful and shocking that there is an estimated 20 million tons of protein going to waste in less developed countries. The residue when you have taken the oil crops, soybeans, cottonseeds, coconut and peanuts, and squeezed out the vegetable oil, has a high protein content, yet little of it reaches humans. It is fed to animals and in many places it is used for fertilizer. What a wretched waste that is!

The first step then should be to use what is at hand and to begin to apply some of the new nutrition technology in the less developed world. So far I have not observed in any less developed countries, in their political leadership, a sense of concern about nutrition. If the current administration is following the short tether policy and requiring agricultural progress is the less developed countries as a condition to helping them, and I hope they are, I would urge that that policy be extended to require a food and nutrition policy as well.

## THE GREEN REVOLUTION AND EMPLOYMENT

The second point I would like to make, and I am sure that Dr. Lester Brown will bring this into sharp focus this afternoon—it is emphasized very well in his exciting new book, "Seeds of Change," to be published early next year—is the question of employment and mechanization.

I think we have made some serious mistakes in the United States in our own agricultural revolution. We mechanized pellmell with the objective of seeing how much we could produce with as little labor as possible. Maybe in the long run it will prove to have been a good thing. But in the process we displaced millions of people and dumped them in the big cities. We are paying the price for this in many ways now.

I think we could have made it possible for some of these displaced people to stay in the areas in which they started, but we ignored that possibility.

One of the elements in the Green Revolution that so far is largely overlooked is the potential for additional employment.

We all know the populations are increasing at a fearful rate in these countries. Actually population increases are exceeding migration to the cities. And that is producing severe consequences. The slums of Bombay and Calcutta, for example, make those of the United States look tame, hard as that is to believe.

In Calcutta there are 100,000 people who just roam and sleep in the streets; they have no home of any kind.

What can be done with these people? How can they get jobs? If somehow they could have an income they would become a real factor in the economy. What a tremendous thrust and stimulus that would be to progress. The buying power of the masses is what is missing. It could trigger the entire economy.

## INCREASED USE OF LABOR

The new cultural practices required by the Green Revolution require a lot of additional labor. They call for careful seedbed preparation. They require the application of fertilizer selectively and well.

They take exhaustive weeding or the weeds will soak up the fertilizer. They require the careful application of pesticides. In some instances, double, triple, and even quadruple cropping will take place.

All of this demands increased use of labor. As the Green Revolution goes forward, we ought to follow policies of selective mechanization. Machinery should be used where it will increase both production and labor.

Irrigation is a good example, calling for the use of pumps to lift the water. If you can get the water, you can produce two, three, and four crops a year. That means a sharp increase in the demand for labor. We ought to mechanize irrigation aggressively. In many less developed countries there is a shortage of labor in peak periods, during planting and harvesting. That is when machinery should be used to meet heavy seasonal labor needs. But otherwise, the policy should be to maximize the use of people. In the process, you can maximize the production from the land, for intensively working the land with people will out produce mechanization.

The objective ought to be not the greatest per man-hour output, but rather maximum production using the greatest labor consistent with total output goals.

### POLICY OF SELECTIVE MECHANIZATION

A policy of selective mechanization ought to be designed in each country and region and carefully followed. If that is done, jobs for people, the key to development and progress, can be significantly expanded.

In the long run, if we could get employment at a level where people have money to spend for food, the problem of food, hunger, and nutrition will take care of itself, for people will eat if they have the money to buy.

Each country, I would urge, should carefully review and examine the potential of the Green Revolution to provide jobs. I would like to see U.S. policy directed to maximize that use of labor in the agriculture of the less developed countries. In that way, we could make a very, very important contribution to the less developed countries and spark the so-called takeoff point economically by creating purchasing power in the rural areas of the less developed world.

I hope those two comments, nutrition and maximum labor utilization, contribute to the discussion. Thank you, Mr. Chairman, for the privilege of participating.

Mr. THOMSON. Mr. Gaud.

## STATEMENT OF WILLIAM S. GAUD, EXECUTIVE VICE PRESIDENT, INTERNATIONAL FINANCE CORPORATION, WASHINGTON, D.C. (FORMER ADMINISTRATOR, AGENCY FOR INTERNATIONAL DEVELOPMENT)

Mr. GAUD. Thank you, Governor Thomson.

Mr. Chairman, members of the committee, and ladies and gentlemen, I would like to say a few words, and they won't be too many, about the effect the Green Revolution has had on the U.S. aid program. And

it has had an effect, not only on our own aid program but also on the aid programs of the World Bank and other aid givers.

Indeed, it has had a very profound effect. For many years, most of us in the development business have felt that too little progress was being made in agriculture in the developing countries—completely inadequate progress.

We felt this primarily for two reasons: First, the individual developing countries are mainly rural. Their population is rural. They are agricultural in nature and in character.

### PROBLEM OF LAGGING FOOD PRODUCTION

You can't get overall development in a country most of whose population is rural and agricultural unless you can move the agricultural sector and the agricultural sector wasn't moving, which was holding back progress. The efforts of a lot of people to concentrate on the more dramatic business of industrialization just wasn't getting the country anywhere.

But the lack of progress on the agricultural front was important in terms of another overriding world problem and that was the fact that for a good many years the demand for food has been rising faster than the production of food. This was due to two things: the population explosion, and rising incomes in the developing countries which enabled the people in those countries both to eat more food themselves and to feed more grain to cattle in order to get meat.

The result was that, worldwide, the demand for food was outracing the supply.

There was an easy answer to that—the one Orville Freeman just referred to. Let the United States and the other surplus food producing countries provide food to the poor countries who weren't growing enough themselves.

This may look like an attractive answer in the short run. But it is a very poor answer in the long run. It doesn't get anybody anywhere in the long run. As the Secretary said, we, in the last few years, have recognized this and have been following a short tether policy with our food aid.

The only sensible answer to this problem is to increase food production in the countries that aren't growing enough food, and that can grow more food. There are quite a lot of countries with both these characteristics.

As I say, and as Dr. Myers pointed out, people have been working on the question of how to increase food production for a good many years. This is not an example of instant development.

### ELEMENT OF DRAMA IN NEW SEEDS

A great many things have been going on which have had a cumulative effect. But, by the grace of God and a stroke of tremendous good fortune, only a few years ago the research activities of the Rockefeller Foundation, the Ford Foundation, and others culminated in the production of the new varieties which produce so much more food than the old.

Intrinsically, this was a tremendous development. But from the standpoint of someone in the aid business, as I was, it was also important because it added an element of drama, an element of excitement—some sex appeal, if you will—to agricultural production.

Any man who saw his neighbor using the new seeds could see for himself what they could do. Their use spread rapidly in countries like Turkey, India, Pakistan, and the Philippines because individual farmers could see for themselves what a difference they made.

The normally complicated business of the development process—how to get a country to develop, how to get people to change their attitudes—suddenly came down to a very simple proposition: one man seeing his neighbor doing better than he was doing. So these seeds had a tremendous effect, and they made the job of increasing food production much easier than it had ever been before.

### HOW AID RESPONDED TO OPPORTUNITY

They made possible a huge quantum jump in agricultural production.

We in AID tried, as did others in the aid business, to make the most of this opportunity. We impressed on all our personnel both at home and abroad, and on all our customers, that increasing food production was our first concern—our first priority.

We reoriented our programs in this direction. We changed our organizational structure here in Washington. We sent more people out into the field to work toward this objective. We emphasized it in the areas of training, of technical assistance and of capital assistance—where, for example, we concentrated more than before on financing fertilizer factories. And today people are more ready to build fertilizer factories in the developing countries than they used to be, though still not ready enough. Similarly, with respect to program loans, we concentrated on financing fertilizers, pesticides, and other necessary agricultural inputs.

In terms of policy guidance, we tried to persuade the developing countries to adopt and follow policies which would furnish incentives to farmers to grow more food.

All along the line we tried to push this matter of more food production above everything else. We talked about it to all who would listen.

The results, as you have heard from a couple of the speakers this morning—and as most of you already know—have been significant. Not particularly because of AID's efforts, but because everybody has caught this bug and has been working on this problem over the last few years.

The results are real. They are substantial. They are continuing. But the most important result, it seems to me—and I am looking at this again from the standpoint of one in the development business—is that the benefits of the new agriculture have been so evident and so demonstrable that the initiative in demanding increased food production has shifted from the aid-givers in the developed countries to the governments and citizens of the developing countries.

### LDC'S HAVE CAUGHT IDEA

It is the South Asian peasant, the agricultural ministers of developing countries, who are demanding more fertilizer, seeking more training, asking for research institutes, better seeds, and the other elements of the new agriculture.

We are not pushing them anymore. They are pushing us. And that is real progress when you are talking about development.

Before I close, let me be sure I am not misunderstood. I want to underline very heavily what has been said by Secretary Hardin and Dr. Myers. It is not all sweetness and light. Everything is not coming up roses—or even wheat and rice.

We are at a very early stage of what can be—and I emphasize can be—a real breakthrough in agricultural development.

Bnt the outcome is far from certain. For example, most of the progress to date has been made in a very few countries. They are important countries, but they are few in number and nearly all of them are in Asia.

There has been very little progress in Latin America or in Africa. I have the same confidence that I believe Dr. Myers and others have that these new research institutes in Nigeria and Colombia will contribute to progress in those areas.

### REQUIREMENTS FOR THE FUTURE

But it is going to take continued hard work on our part and on the part of the developing countries to capitalize on the progress that has been made to date. There must be continued attention to research. Also, the LDC's must continue to follow sensible agricultural and pricing policies; they must continue to devote large parts of their scarce foreign exchange resources to fertilizer and other necessary inputs; and there must be continued emphasis on technical assistance and training. As has already been said, they can't do this by themselves.

Orville Freeman has a most important point in this business of employment. Agriculture is and should remain labor intensive in many of these countries.

Don't let us be misled by our own past and our own experience. Here, again, one has to remember, as one does all through the development process, that it is not a matter of just taking over to those countries what we have been doing here.

We have to adapt to their conditions, their requirements, and their needs. In agriculture, mechanization has worked for us. But it will not necessarily work for all of them—particularly at first. Remembering that fact is one of the keys to future progress.

I would sum up this way the situation that exists today: Thanks to the new varieties and the other elements of the new agriculture, some of the developing countries have turned an important corner much sooner than any one of us would have thought possible as little as 5 or 6 years ago. But they are still a long way from home, and most of them haven't even started yet. So there is still plenty to be done.

Thank you, Mr. Chairman.

Mr. THOMSON. Thank you, Mr. Gaud.

Now we will hear from Dr. Hardin.

## STATEMENT OF LOWELL S. HARDIN, OFFICER FOR AGRICULTURE, LATIN AMERICA AND THE CARIBBEAN, THE FORD FOUNDATION, NEW YORK, N.Y.

Mr. HARDIN. Thank you, Governor Thomson, Mr. Chairman, fellow panelists: The analyses that have been made thus far, it seems to me, show how the Green Revolution is contributing to enlarged food supplies for the hungry, better nutrition for the malnourished, and improved quality of life for the less advantaged.

What my brief discussion will attempt to do will be to supplement the foregoing comments with some generalizations on what is taking place, why, and suggest some possible implications.

As has been pointed out, international research teams have demonstrated that man can develop higher-yielding, more efficient plants. Success with new production packages for wheat and rice have helped to create an environment conducive to an escalation of biological advances.

### FOUR CONDITIONS OF FOOD TECHNOLOGY SPREAD

The production package idea has gained widespread acceptance as a research and testing concept and as a vehicle for demonstration, education, and the spread of new technology.

Let me try to point out four of the characteristics of the situations in which new rice and wheat production technologies have spread most rapidly.

### I. SUPERIOR "PRODUCTION PACKAGE"

First, a superior production package was tested and at least almost ready for use. Opportunities to raise output per acre not by 5 percent, not by 10 percent, but by 100 percent or more, and to increase profits did in fact exist.

In other words, the technological guns were loaded. Farmers and education were not shooting blanks.

### II. COMMITMENT BY GOVERNMENT

Second, commitment and leadership were provided by governments. Education, training, and applied research were supported. This was not a promotion by outsiders. Most of the work that was done was done by the nationals in the countries.

Actions were taken to reduce the price and income uncertainty that farmers faced. That fact has to be underlined. The absolute level of prices is often less important than the degree of price and income uncertainty which a farmer faces as he considers adopting and applying new production technologies.

### III. DOMESTIC FOOD DEFICIT

Third, a domestic food deficit situation existed.

The comment has been been made that we have seen relatively little of the Green Revolution in Latin America. Most of the countries in Latin America did not have the pressure on food prices that existed in India or in Pakistan. Malnutrition is a problem, yes. But domestic deficit of calories was not such that food prices came under sharp pressure in the Latin American countries, or in most of the nations in Africa.

With deficit-induced high food prices, highly favorable factor-product price relationships were maintained—at least up to that point the domestic requirements were met. Rice and wheat in West Pakistan are cases in point. Imports, in a deficit situation, were cut back as domestic production rose.

This is a fairly easy kind of an operation to manage up to the point that import substitution needs are met—if one has the technology. Internal product prices were set at high levels which bore very little relationship, at least at the onset, to world prices.

The foregoing conditions do not necessarily prevail in many other developing nations about which we are now asking: Why has not the Green Revolution moved more rapidly?

### IV. COORDINATED PRODUCTION EFFORT

Fourth, the production acceleration effort was programed so that more of the required purchased inputs were made available and made available on schedule.

Uncertainties were reduced. National organizations and external assistance agencies got together. These were not programs that ran as parallel efforts. They were one program. Jointly, the national organizations and external assistance agencies manned, planned, and helped execute the effort.

Perhaps the unsung hero of the Green Revolution is the farmer. The lengthy arguments that farmers are irrational, that they do not respond to opportunities for enhanced earnings, have, in my opinion, been largely laid to rest.

Farmers have rather consistently responded when it was clearly in their interest to do so.

Governments are, in my opinion, today, more than formerly, aware of and interested in agriculture as a contributor to development. Planners are coming to understand that farming is a technology-based rather than primarily a resource-based industry.

For example, in Argentina, they are now beginning to realize that the Pampas are not an inexhaustible resource; that technology has a place in changing agriculture and perhaps in changing the rate of overall development. Argentina is a nation where at least the agricultural sector until recently was characterized by stagnation.

Thus, it has been clearly demonstrated that commodity-centered and research-based production thrusts can, at least under these four conditions outlined, increase production. Nevertheless, rising output, be it industrial or agricultural, is but one of the changes essential

to an enlargement of human choice. The leap between a successful crop production program and total development is indeed a great one. Rice is a case in point. Over an extraordinarily short period, scientists at the International Rice Research Institute have essentially redesigned the tropical rice plant.

AREA AFFECTED: POSTAGE STAMP ON GLOBE

They have evolved, tested, and helped to place in use a new set of yield-increasing practices. As a result, a technical foundation now exists for new, high levels of tropical rice production. The advanced technology, however, fits ideally that relatively small portion of monsoon Asia where the paddy is most productive.

At a recent conference at IRRI, the scientists estimated that in South and Southeast Asia only 20 percent of the riceland is under controlled irrigation.

This 20 percent of the land probably accounts for about 40 percent of the production. But the other 80 percent of the acreage is dependent upon natural rainfall.

Rice production on rain-fed fields and especially on upland soils has thus far been little influenced by the recent technical advances—except that those who raise rice under the less advantageous conditions now face lower prices for their product. The same is true for wheat.

To date, most of the nonirrigated rice- and wheat-producing areas of Asia have been little helped. The first need was for more food. This need is now being met by yield increases on land where rice and wheat grow best.

If you take a small-scale map and look at it, sometimes I think that the geographic area where this new technology, the Green Revolution, applies best appears as a postage stamp on the face of the earth.

The Green Revolution is not, therefore, a package that is ready to go, here, there and everywhere.

One of the dangers is that we think that the world has all of the needed technical and economic answers. We push programs but nothing happens—because the adapted technology that is required is really not yet in hand.

Because of the work that has been done, supplies of rice and wheat are now available—and available at lower prices. From the consumer's viewpoint this is great. Translation of this gain, the more sure supplies of foods at lower prices, to the improved welfare of all requires improvements in distribution and employment opportunities, to which Secretary Freeman just referred, as well as in production. More is now known about the requirements for production than is understood about the social consequences of technological change.

Shifting to the Americas, let us look at the Green Revolution from the viewpoint of the South American farmer. This farmer sees his problem less as one of increasing his output than of expanding the domestic and foreign market for his products.

Access to more steady jobs, the ability of consumers to buy, the worsening plight of the many marginal farm families—these are the pressing concerns of most developing nations today.

Moves of other countries towards narrow national self-sufficiency bother the Latin American farmer, too.

The South American nations, generally speaking, are net exporters of agricultural products. The new technologies associated with the Green Revolution tend to be unit cost reducing. Because of this fact, if Latin American nations are to compete in world markets, they, too, must keep up with the cost-reducing advantages of improved agricultural technology. Generally, these are output increasing, unit cost reducing and they require a substantial investment in research, testing, adapting, and fitting it to local conditions.

### ABUNDANCE: "A PROMISE, NOT A REALITY"

In conclusion, then, widespread abundance, as has been pointed out, is still a promise, not a reality. Modernized agriculture does not in itself guarantee plentiful, low-cost food or full employment. Properly managed, though, technological advances in agriculture can provide part of the ingredients of a better tomorrow.

Through imaginative, persistent applications of science, man has demonstrated his ability positively to disrupt traditional, low levels of equilibrium. Perhaps it is through its pragmatic demonstration that man need not be satisfied with an unsatisfactory lot that the Green Revolution speaks most eloquently.

Mr. THOMSON. Thank you, Dr. Hardin.

Mr. FRASER. Mr. Chairman, I have a note about the questioning. As I understand the ground rules, the members have the first opportunity. I will see which members do have questions. Even though I am a junior member of the committee, I will follow the seniority system and call on our chairman first.

### HOW CAN COOPERATION BE IMPROVED?

Mr. ZABLOCKI. In your presentation, Dr. Myers, and all three of the panelists, former Secretary Freeman, Mr. Gaud and Dr. Hardin, you have touched upon the necessity of cooperation, the need of a cooperative effort among all agencies and organizations, and particularly with the participating countries, the developing countries.

My question to Dr. Myers and the panelists would be: In what way can the cooperation be improved?

Further, if we can get necessary cooperation with friendly countries, would it be desirable and advisable to have the Green Revolution, our agricultural technology, made available to unfriendly countries, mainland China, for example?

I know this is a difficult question to try to answer under our 5-minute rule. I hope Mr. Fraser will be very cooperative in permitting the panelists to take a bit more time than 5 minutes.

Dr. Myers, would you care to comment? How can cooperation be improved, and do you foresee any possibility of making available agricultural technology to mainland China?

### A GROWING EFFORT AT COOPERATION

Mr. MYERS. Mr. Chairman, this is, as you have said, not an easy question to answer.

There is, I am convinced from my own experience, a growing effort being made by the various agencies involved in extending assistance to the developing countries to coordinate their efforts to cooperate

where that is appropriate, and at least to be certain that their efforts are synergistic rather than conflicting.

This is developed in a number of ways. Dr. Hardin and I are, I believe, the only ones present today who had the pleasure to attend a meeting which the Rockefeller Foundation hosted in Italy last April of the heads of the major multilateral and bilateral technical assistance agencies. The meeting was designed primarily to foster mutual understanding of what the problems are and what the roles of each agency—the World Bank, the regional banks, the U.S.-AID, the Canadian International Agency, UNDP, and others—are and how these agencies could perform their roles more effectively.

There will be a meeting in Italy in February of the next level of people in these agencies, the people who have direct responsibility for their agricultural programs, to discuss more in depth how their efforts can be coordinated more effectively, to reduce necessary overlapping and to produce a catalytic effect which will cause 2 plus 2 to equal 5 instead of only 4.

### COUNTRY-BASED CONSORTIUMS

Some of the most effective coordination is done at the country level. In many countries there is an informal and in some a formal consortium of people working within the country from the various external agencies—the World Bank, U.S.-AID, the foundations, FAO, and so forth. The local representatives get together periodically to develop a better understanding of what they are doing, why they are doing it, how they are doing it, and how they can improve their programs.

I believe each agency has always worked carefully to develop cooperative relationships with institutions of the host country. This is extremely important, to be sure.

Furthermore by working through and with the host country institutions, the efforts of the external agencies tend to be better coordinated.

Finally, I suggest that cooperation and coordination cannot very easily be dictated from the top. It is dependent so much on the individuals involved that in some places and in some countries we can expect it to be much better than in others, simply because the people involved want to cooperate and make greater efforts to work together.

### THE GREEN REVOLUTION AND RED CHINA

In reply to the second part of your question, I believe we can and should develop more effective working relationships and cooperation in agricultural development with some of the less friendly nations, in spite of the difficulties of doing so.

One of the mechanisms whereby this cooperation can be developed is through international institutes which we mentioned. The institutes are not only international but, in a real sense, apolitical.

The staff and scientists of the International Rice Research Institute are, for example, not only permitted access to Burma, but are invited by the Burmese to come in to help them set up their agricultural experiments, to bring their materials in for testing, and to come back to help them evaluate the tests. Institute scientists have such access

because the institute is international and, therefore, presumably does not favor one side over the other.

We have some reason to believe that the improved rice varieties from the Rice Research Institute, and the dwarf wheat varieties from Mexico are already being used in North Vietnam and in Red China. Of course, we don't really know, because none of us has access to this kind of information, but there have been such rumors at least.

There is much to be gained, it would seem to me, because if people are less hungry and less in want, they may be less difficult to live with.

### RECOMMENDS "SHORT TETHER" POLICY

Mr. FREEMAN. In terms of cooperation, I think it is obvious that how you cooperate will depend in considerable part country by country, and you have to realistically face the differing kinds of economic and political problems of special countries.

In that connection, I think we are increasingly using the private sector in some of these things more effectively. One of the wholly-owned subsidiaries of EDP Technology with which I am now associated is International Development Services.

We have contracts in a dozen or so countries around the world, and there are things that can be done in various places. You can cooperate more effectively sometimes if it isn't direct government, per se.

I might say to you, Mr. Chairman, and the committee, that there is an old saying you have to put your money where your mouth is.

If we are going to want to cooperate, want to further this, we will have to have an aid program and it will have to be financed and supported, and we will have to have some horses to work with.

I would say that would certainly be one of the most important ones. But recognizing we can't force things on people, by the same token, I think we ought to be very firm. It was my experience that the short tether policy is an important one, that if we go into a country and we are anxious to help them, they have to want to help themselves.

That is a matter of judgment in the individual countries, but I think it ought to be followed and we ought to have a tough-minded policy in connection with it, and not throw away resources in a place where they are really not prepared to do anything.

If they are, try to cooperate, but cooperation is two-sided. There is an old saying that you cooperate and I will operate. That is not the kind of cooperation that will get things done.

### CANNOT LOCK UP TECHNOLOGY FROM CHINA

I think in connection with China, that is an academic question at the moment. They don't want to talk to us about anything, trade or anything else.

Therefore, we can't do very much about it. But they do exist in the world. I think it is the policy of this country, and properly so, that we should try and talk with them. A very eloquent language is the language of food and agriculture.

For my part, we couldn't lock up this technology if we wanted to. If I were making the decision and Communist China wanted to have us cooperate with them in trying to strengthen their agriculture, I would vote "yes" and be prepared to do so.

RECOMMENDATION OF PEARSON COMMISSION

Mr. GAUD. Mr. Chairman, may I add just a word on this business of cooperation?

I agree entirely with what Dr. Myers said.

It might be worth noting that the Pearson Commission dealt with this question at length. It is discussed in their report, "Partners in Development," which I am sure you are all familiar with.

They come up with a concrete suggestion, after pointing out the difficulty of trying to get a disparate bunch of organizations to work together: bilateral aid agencies, multilateral aid agencies, private foundations, developing countries—none of them with a common boss. How do you get them to cooperate and work together?

In an ideal world, each developing country would coordinate all of the aid that was offered to it. But the developing countries are not up to doing that. So we have to rely on some other means of doing it.

The concrete suggestion that the Pearson Commission made—if you can call it a concrete suggestion—was that the President of the World Bank should call a conference within the next 6 months or so of the heads of the various organizations and agencies involved in the aid business, and try to work out some more effective method of cooperation.

I suppose you might say in a way that that was an admission of failure in that they were not able to come up with a specific suggestion themselves. But if it is, I wouldn't criticize them for it. I don't think any of us know how to go about this.

I do believe that the degree of cooperation has improved enormously over the last 6 or 8 years. Its effectiveness has improved enormously over the last 6 or 8 years. There are still a lot of rough edges. I hope the United States will support the suggestion made in the Pearson Commission that a try be taken at working out some overall method of coordination such as they suggest.

"MIRACLE RICE" IN CUBA

Mr. HARDIN. I have two comments. It has been our observation that cooperation comes at the national level when you have answers that are useful to people or ways to get to those answers, and your cooperation is problem focused rather than organization focused.

We have heard that Cuba, for example, is using IR–8 on some portion of her rice acreage. We do not know for sure that they are. If the new varieties are being used, we do not know how they got there.

But Cuba had a rice production problem, presumably. There were helpful answers to the problem. People are being served presumably because something concrete had been done about the problem. I agree with the comment that science really knows and should not know any international or diplomatic barriers.

There are ways to move that which is known across man-made barriers. Perhaps such movement is in part achieved by a symposium such as this. We get down to what we really know, what we think we know, and what we don't know about how to solve some of these kinds of problems.

Mr. ZABLOCKI. Thank you. Mr. Fraser.
Mr. FRASER. Mr. Brown had his hand up.
Did you have a question on the same point?
Mr. BROWN. On the same thing.
Mr. FRASER. Why don't you add your comment?

LACK OF COORDINATION IN CONGRESS

Mr. BROWN. On the question of coordination and cooperation, I think a number of the developing countries are finding themselves in a dilemma today. As they attempt to modernize their agriculture, their requirements for food aid invariably begin to decline. At the same time the need for fertilizer and other farm supplies rises. But these two forms of assistance, food and fertilizer, are not coordinated in the sense of their being no mechanism to offset, even partially, declines in food aid with increased aid in other forms such as fertilizer. Food aid is the responsibiltiy of the Agriculture Committee and fertilizer and other forms of aid of the Foreign Affairs Committee; and there is no formal coordinating mechanism between these two committees. As a result, countries successfully modernizing their agriculture find that they are being penalized by a decline in assistance available from abroad for development.

Mr. FRASER. Thank you.

I can help answer that in one way. Our committee would like to take back jurisdiction over the food for peace program.

But I think we made one effort and got nowhere on it, so it remains an unsolved problem.

Mr. Adair?

Mr. ADAIR. No questions, thank you.

Mr. FRASER. Congressman Findley.

Mr. FINDLEY. Thank you very much, Mr. Fraser.

DO FOUNDATIONS GET MORE FOR MONEY?

I have two questions for Mr. Myers. First, why does it appear that the investment by foundations seems to pay off so much better than investment through AID? That may be an oversimplification, but one gets that impression from reading about the many successes which have been largely developed from foundation investment as opposed to AID investments.

If there is such a disparity in the investment-benefit ratio between foundation money and government, what can we do to improve the ratio at the governmental end?

My second question relates to the appendix item on Mexico which indicates that Mexico is today drawing interest at the rate of 600 percent per year on all of the investment made jointly by the Government of Mexico and the Rockefeller Foundation in its corn and wheat improvement program.

I observe that that estimate figure does not include the investment, a very substantial investment, made in irrigation, which would help to account for the good yield they have had. I raise these two questions for whatever comment you may wish to make.

ECONOMIC ANALYSIS OF EFFECTS OF NEW SEEDS

Mr. MYERS. Let me attempt to answer the second question first. With regard to it, I must plead some lack of knowledge. As you will note, it is Dr. Schultz of the University of Chicago who is being quoted in this case. I am not sufficiently well acquainted with the economic-analytical techniques which were used by Dr. Schultz and his students in making this kind of an analysis to give a categorical answer.

It is my understanding, however, that so far as possible in the economic analysis, Dr. Schultz and his students have removed the effects of other factors that were involved in expanding agricultural production, and thus have derived a percentage figure based on the contribution to agricultural production in Mexico resulting from the investment in agricultural research and extension programs. If my assumption is correct, and I believe it is, the factor of the investment in irrigation facilities, for example, has been removed in their analysis of the benefits from the investments in agricultural research.

CAPABILITIES: FOUNDATIONS VERSUS GOVERNMENT

The first question is more difficult to answer precisely. It is easy to take a major success story such as the high yielding varieties and other technologies generated by the foundations' investments, and to assume, therefore, that everything the foundations do is equally successful. We like to hope that it is, but it probably is not always. We were working in this case on a sufficiently tangible, controllable and important aspect of the total problem, that the results from the foundations' programs had a very large effect on agricultural development. We must remember, as Dr. Hardin pointed out, that a number of forces also coalesced to cause the Green Revolution.

It would be unfair, therefore, to conclude that we are so much more efficient in our operations than United States-AID is. I would like to think we are, but I would not want to try to prove that we are.

I would suggest some capabilities the foundations have, perhaps not available to United States-AID, which might be factors in their apparent successes.

In the first place, the foundations can select the problems on which they focus and the places where they work purely on the basis of merits as assessed by their officers. The foundations cannot and are not expected to work everywhere on everything.

Second, there is the ability to plan well into the future, knowing that if the trustees approve a program will be supported for as many years as necessary. We are, therefore, able to recruit for our staff highly dedicated career scientists who know that they will be continued on the staff for so long as they continue to do the job expected of them. They know that if they are so successful in getting a program started, in establishing an institution, and in training indigenous people to take over that they are no longer needed there, that we will have some other place for them to go and something else for them to do. They can, and we expect them to, work themselves out of a job.

There is no substitute in a scientific program for continuity, ability to plan in advance, ability to react flexibly as one moves ahead

and assurance that the resources will be available to carry on the program to its logical termination.

I would suggest that we might give more consideration to long range planning and commitment in our Government international development efforts.

Mr. FRASER. Thank you, Dr. Myers.

Do any of the panel want to comment further on either of the two parts?

GOVERNMENT ROLE IN GREEN REVOLUTION

Mr. GAUD. I would like to add a word on that. It seems to me that the foundations and aid agencies such as AID have complementary roles. I agree entirely with what has just been said, that an aid agency, and I don't care whether it is the U.S. AID agency or any other aid agency, isn't the best organization to carry out a long-term research function.

I think this can be handled better in the private sector. But I do think that the aid agency can perform a useful role in putting up some of the money that is needed just as AID, the Canadians and others are now putting up funds to help support these research institutions we have been talking about.

But I deplore any suggestion that AID take over what I believe to be the foundation's part of the Green Revolution. I think AID's job is a very different one. Just as a foundation has great advantages in carrying on a long-term research job, AID, if it is given the resources by the Congress, is better suited than the foundation to carry on a large-scale training effort, to carry on large-scale technical assistance efforts, to provide fertilizer under nonprogram loans, and to help build fertilizer factories.

I think, Mr. Findley, it is a question of rendering unto Caesar what is Caesar's and rendering unto God what is God's. I don't think the two situations are really comparable.

FOUNDATION WORK: "TIP OF ICEBERG"

Mr. HARDIN. It seems to me that some of the things the foundations have done emerge as the tip of the iceberg. If you look at India and Pakistan in terms of what actually happened to move the rice and the wheat, the varieties were only the handle to the package.

Where did the fertilizer come from? How did it get there? How were the people trained? How was the irrigation planned and financed? How did the whole organizational structure get established at the village level and up?

These represented inputs not only from United States-AID but from national and multinational agencies all across the board. It is grossly unfair to say that any one entity was the architect of this whole job.

It was a team effort. It required very substantial resources, human and financial, that did not and could not come from the foundations. The total requirements were completely beyond the capabilities of the foundations.

Mr. FRASER. Any other questions from members of the subcommittee?

Are there any questions from the audience?

FUTURE ROLE OF FOUNDATIONS

Mr. LYLE SCHERTZ (U.S. Deparment of Agriculture). Mr. Gaud, you suggest that the long-term research effort is in the province of the foundations. I then in turn wish to ask Dr. Myers: Do you see the resources from the foundations to do the research task that you outlined earlier?

Mr. MYERS. I listened especially to the latter part of Mr. Gaud's statement, that is that much of the financial resources for some of the long-term research efforts can and should be provided, as they are now beginning to be, by U.S.-AID, Canadian International Development Agency, and others.

The foundations do not have the resources to do any more than a small fraction of the total research work that needs to be done in getting agriculture moving in the developing nations.

We have helped, as I indicated, with the establishment of the international research institutes. They are now seeking support from other sources in addition to the foundations. It is our hope that the time will come fairly soon when we will be minor contributors to the ongoing research efforts of these and possibly other institutes that may be developed and that AID and others will be the major financial contributors.

If I understood Mr. Gaud correctly, he did not suggest the funds should not come from such sources as AID; rather he was talking about the continuity of management, career staffing, et cetera.

Mr. FRASER. The time is now 11:30, so we have to end this panel's discussion. On behalf of the subcommittee, I extend our thanks to Dr. Myers, Secretary Freeman, Bill Gaud, and Dr. Hardin. I think we owe them all a round of applause.

[Applause.]

## SESSION II: THE POLITICAL, SOCIAL, CULTURAL, AND ECONOMIC IMPACT OF THE GREEN REVOLUTION

INTRODUCTION OF DR. MOSHER

Mr. ZABLOCKI. I will now call upon the ranking minority member of the committee, the Honorable Ross Adair, to introduce the next speaker and to present the panelists for session 2, the political, social, cultural, and economic impact of the Green Revolution.

Mr. ADAIR. It is my privilege, Mr. Chairman, to introduce the author of the second major paper to be presented here today, Arthur T. Mosher, president of the Agricultural Development Council of New York City.

Dr. Mosher has been active in rural technical assistance since 1933. From that year until 1953 he was closely connected with the Allahabad Agricultural Institute in India, engaging in a number of experimental programs of extension methods, and serving as principal of the institute from 1948 to 1953.

From 1953 to 1955, Dr. Mosher was visiting research professor of economic development and cultural change at the University of Chicago, from which he received a Ph. D. in 1946.

After serving at Cornell University from 1955 to 1957 as director of a seminar on comparative extension education, Dr. Mosher was appointed executive director of the Agricultural Development Council in 1957 and became president of the council in 1967.

The author of several books, the most recent being "Getting Agriculture Moving" (1966), he has written numerous articles on problems of agricultural development and served for several years as chairman of the Research Advisory Committee of AID.

Dr. Mosher will discuss the political, social, cultural, and economic impact of the Green Revolution.

## STATEMENT OF ARTHUR T. MOSHER, PRESIDENT, THE AGRICULTURAL DEVELOPMENT COUNCIL, NEW YORK, N.Y.

Mr. MOSHER. Congressman Adair, Mr. Chairman, ladies and gentlemen, I think it is already evident that throughout the day we are going to have considerable overlapping among these topics, moving back and forth among them.

This is probably just as well. So far, at least, we have not had any violent differences of opinion. I think this is one of the hopeful signs of what is happening with these new varieties.

One of the contributions they are making is to help us see the whole range of tasks involved in agricultural development and of economic development more broadly.

In outlining the major economic, political, social, and cultural implications and effects of the "green revolution," it seems to me to be useful to divide them into three groups.

First, there have been a number of effects of a completely positive nature that are important and far-reaching.

Second, there is a group of effects that confront us as problems primarily because we were not ready for them.

Third, here is a set of problems brought on by the Green Revolution that confront us with hard policy questions involving national goals both within and beyond agricultural production itself.

Some of the problems that these create must be faced. We could refuse to become concerned about others of them, but a refusal to become concerned about others of them, but a refusal to begin to face them now might lead to much more serious problems in the future.

### I. EFFECTS THAT ARE WHOLLY CONSTRUCTIVE

There are many results of the Green Revolution that are unambiguously constructive. It has brought an appreciable increase in food supplies that buy valuable time in the race between food production and population increase and that simultaneously make increased development activities feasible without causing inflation.

It has substantially increased incomes of important segments of each national population. It has brought a pervasive upsurge of confidence spreading through the countryside and the political capitals of important parts of the world.

It has resulted in much greater attention being given to agricultural development by national governments who now see that their domi-

nantly agricultural base need not be a disadvantage, but can make very substantial contributions to general growth.

It has resulted in greatly increased private investments in farming. Millions of farmers now realize that farming can be profitable and that it can repay capital invested in it at a very satisfactory rate.

It has resulted in much greater private investment in agribusiness enterprises; those businesses that supply farmers with production inputs and that market and process farm products.

It has, of course, resulted in a greatly heightened awareness of the value of biological research. It is now widely realized that the pathway to a modern agriculture begins with the application of modern science and technology to the problems of farming.

And there is now widespread recognition that new varieties of crops can be the carriers of a whole new technology of farming.

Finally, the changes brought about by the Green Revolution are demonstrating the interlocking unity of rural and urban, and of agricultural and industrial development. In doing this they are introducing a new realism into general planning for development.

Special note should be made of the encouragement the Green Revolution has given to foreign aid agencies, both governmental and foundation.

All have had a hand in it although it was the Rockefeller and Ford Foundations practically alone that began and carried through the most important research activities that made it possible.

Later, international and bilateral aid agencies played important notes. They all now know that this kind of cooperation can be highly effective.

Some of these effects constitute objective gains already achieved—the gains in food supply, foreign exchange conserved, new investments completed, new patterns of organizational cooperation—while others change the social, economic, and political climate in ways that facilitate additional gains in the future.

### II. EFFECTS THAT REVEAL DEFICIENCIES

The second set of influences of the Green Revolution grows out of the unpredicted suddenness with which production increases have been achieved.

Up until very recently, the predicted rate at which it seemed likely that production increases could be achieved was slow enough that it was assumed that other problems that might be involved could be handled fairly easily as they arose.

Contrary to all predictions, the spread of the new varieties of wheat and rice in certain parts of Asia has been extraordinarily rapid and each nation has been caught unprepared.

It has been estimated that the area in the new high-yielding varieties in Asia increased from 200 to 34 million acres within the period of 4 years from 1964–65 to 1968–69.

It is no wonder, therefore, that serious deficiencies in arrangements for keeping up with such rapid expansion have been encountered.

ESTIMATED ACREAGE IN NEW HIGH-YIELDING VARIETIES IN ASIA [1]

| Year | Acres |
|---|---|
| 1964–65 | 200 |
| 1965–66 | 37,000 |
| 1966–67 | 4,800,000 |
| 1967–68 | 20,000,000 |
| 1968–69 | 34,000,000 |

[1] Dana G. Dalrymple, "Estimated Area of High-Yielding Varieties of Grains in Ten Asian Nations," International Agricultural Development Service, U S. Department of Agriculture, November 1968 The 1968–69 figure represents goals.

INCREASED DEPENDENCE ON PURCHASED INPUTS

One of the problems that has emerged is the rapidly increasing dependence of farm production on purchased inputs—seeds, fertilizer, pesticides, and equipment.

The multiplication of pure seed poses problems but the profit to be gained by engaging in seed production is a powerful stimulus to get the job done, and the rapid succession of crop generations made possible by multiple cropping within each year, plus the practice of importing seed from abroad, makes the task relatively easy.

The substantial amounts of fertilizers and pesticides, however, that are necessary to get full value from the new varieties are another matter. The manufacturers of fertilizer requires either very large investments domestically or considerable amounts of foreign exchange if they are to be imported.

Pesticides require less in the way of capital investment but their manufacture is an intricate process, subject to large economies of scale.

In addition to seeds, fertilizers, and pesticides the successful cultivation of the new varieties requires certain types of new farm equipment and in certain circumstances new sources of farm power.

In general, agricultural development as a whole involves only relatively minor requirements for foreign exchange but, unless a country develops its own sources of supply, providing the purchased inputs on which the new agriculture is dependent can make very heavy inroads into a country's limited supply of foreign exchange.

From 1960 to 1967, the percentage of India's total export earnings required to finance fertilizer imports alone rose from 2½ to 20 percent.[1]

Because the Green Revolution has spread so rapidly there is a serious lag in facilities for making available the farm supplies and equipment on which the full value of the new varieties is dependent and accelerated programs to make good these deficiencies are now needed.

RISE IN CASH COSTS OF FARM PRODUCTION

Closely associated with the increasing dependence of modern farming on purchased inputs is an appreciable rise in the cash costs of farm production. The cash returns, of course, can be far greater both to individual farmers and to national economies.

[1] Brown, Lester R., "New Directions in World Agriculture," Second International Conference on War on Hunger, Washington, Feb. 20, 1968.

One estimate places the increase in GNP in India and Pakistan at $200 million and $625 million respectively in 1968 and similar additional increases in 1969.[2]

But in order to achieve these increased returns that are possible each farmer must first incur increased expenditures for the necessary purchase of inputs.

An estimate with respect to wheat in India is that growing a high-yielding variety and practicing appropriate cultivation techniques costs 60 percent more per acre than growing the varieties it replaced.[3]

Estimates with respect to rice in the Philippines have been higher. Whatever the exact increases in a particular location, the result is an enormous expansion in the need for farm credit, and for expansion and modernization of banking and financial facilities through which the credit can be managed and made efficiently available to the millions of individual farm operators who need it.

### INCREASED NEED FOR MARKETING, STORAGE, PROCESSING, AND TRANSPORTATION FACILITIES

If we have been caught short by the rapidity with which the Green Revolution has spread with respect to arrangements for providing the off-farm facilities on which increased production depends, we are equally in temporary difficulties because of a lack of adequate provisions for handling the increased production once it has taken place.

These include facilities for marketing, for storing, for processing, and for transporting the increased production and for financing all of these operations.

The parts of each country where the new varieties have most rapidly taken hold are those where facilities for handling farm products were already developed to a considerable degree, but even there production has been rising much more rapidly than existing facilities are adequate to handle.

### EXPANDED NEED FOR PUBLIC SERVICES TO AGRICULTURE

Every modern agriculture is heavily dependent on a number of services that must be publicly provided. Where these are inadequate, it places an additional constraint on the spread of the Green Revolution.

Farm to market roads to facilitate getting farm products to market and farm supplies and equipment to farms, an agricultural extension service to help farm operators make the best use of the opportunities available to them, a market information service that keeps farmers informed about present and probable future prices, and a set of public policies affecting the prices of farm products and costs of production are all important.

In addition, *national* systems of adaptive and protective research are lagging badly in most countries. The international centers out of

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[2] Borlaug, Norman E.; Narvaez, Ignacio; Aresik, Addvar; and Anderson, R Glenn: "A Green Revolution Yields a Golden Harvest," Columbia Journal of World Business, vol. IV, No. 5, September–October 1969.

[3] Mann, S. K., Moore, C. V., and Johl, S S, "Estimate of Potential Effects of New Technology on Agriculture inPunjab, India," American Journal of Agricultural Economics, vol. 50, No. 2 (May 1968), p. 289.

which most of the new varieties have come can provide basic seed stocks and information that can be applied directly under a large number of local circumstances.

They cannot, however, provide the continuous protective research needed to control varying combinations of pests and diseases, nor can they carry on the adaptive research needed in many areas to determine optimum combinations of cultural practices for regions with particular combinations of soils, moisture availability, markets, and other local factors.

Consequently, a well integrated program of agricultural research in each country is essential as a complement to the major international centers if maximum advantage is to be taken of the new technology.

It should be stressed again that the primary characteristic of each of the foregoing problems is that it represents a lag in making important facilities available.

Meeting each of these requirements will require some adaptation to prevailing conditions in each country but on the whole the technology for meeting these problems is in hand and some start has been made almost everywhere toward meeting them.

What is required now is primarily a greatly increased effort, much more investment, and an improved planning process that helps to keep all of the requirements for a growing agricultural economy reasonably in phase with each other.

### III. EFFECTS THAT RAISE IMPORTANT POLICY ISSUES

The third set of effects of the Green Revolution includes those that raise new and difficult policy issues for each country.

How these are handled will have considerable repercussions on rates of economic growth and on the social desirability of the outcome. Because they will differ from country to country and because the interactions among them vary we do not know as much about them as we need to.

They are, therefore, problems with respect to which we need considerable additional research as well as prompt attention.

### TENDENCY TOWARD LARGER FARMS

One tendency that is already evident in a number of places is toward expanding the size of individual farms. As men with managerial ability and access to capital see the profitable opportunities in farming, using the new varieties and associated cultural practices, many of them take steps to secure control of increased amounts of land to which they can apply their managerial skills.

One result of this is to bring good land under the management of profit-oriented operators who can finance the new technology, thereby increasing gross production.

To the extent that there are real economies of scale of larger farms this also results in increasing the competitive advantage of large farmers over those whose farms are still small.

These two tendencies, taken together, are likely to lead progressively toward an agriculture made up of fewer and fewer farms. That has

been the usual development, except in Japan and Taiwan where steps were taken to prevent it.

It can be a wholesome shift, *if* adequate nonfarm employment opportunities exist for those forced out of farming, but in most of the developing countries that condition does not prevail now nor will it for several decades to come.

### TENDENCY TO MAKE FARM MECHANIZATION MORE PROFITABLE

A second effects requiring policy attention is the tendency of the new technology to make farm mechanization more profitable. Some forms of mechanization are certainly to be encouraged: Methods of harvesting and preparing seedbeds more quickly where that is essential to multiple cropping; artificial grain drying where that becomes necessary; the application of power to water pumping for irrigation; and adequate implements for precise fertilizer placement and for pest and disease control measures.

The types of mechanization that are more questionable are those that primarily reduce human labor, even when that is profitable to the individual farm operator.

Mechanization that displaces labor may result in greater profits for those farmers who adapt it, but at a social cost of reduced employment opportunities and, where the importation of equipment is involved, at a cost to the economy in foreign exchange and often of public subsidies.

To maximize farm earnings is not necessarily to maximize social returns.

### VARIED IMPACT ON EMPLOYMENT OPPORTUNITIES

A third substantial effect of the Green Revolution having policy implications is its impact on employment opportunities. This has previously been referred to.

Much has been said about the race between population growth and food production. In the long run, the impact of a high rate of population growth on the size of the labor force and the consequent need for remunerative employment for rapidly increasing numbers of people may prove to be an even more serious problem.

It is not at all clear what the net impact of the Green Revolution on employment opportunities is. On the one hand, because of the more continuous and more careful cultivation that the new varieties require and because of the multiple cropping within a single year that they make possible, the new technologies actually increase substantially the amount of labor that can profitably be employed in farming in the absence of widespread mechanization.

In addition to this, the many agribusiness services that are necessary in order to provide farms with supplies, equipment, and credit, increase employment opportunities to manage and operate them.

The construction and maintenance of farm to market roads that become increasingly important as agriculture becomes more commercial are another source of employment. So are the construction and operation of new irrigation facilities to expand the area within which the new technology can be used.

And if the increased production made possible by the new technology results in substantial increases in rural incomes with a consequent increase in the rural demand for urban-produced consumer goods, then to that extent the Green Revolution increases employment opportunities in consumer-oriented urban industries.

Despite all of these ways in which the Green Revolution can increase employment opportunities, the net effect that it will have is unknown. To the extent that the increased profitability of farming for those who have access to resources causes them to mechanize in ways that reduce the amount of labor required in farming, the net effect is bound to be much less than the various increases in employment opportunities that I have just mentioned would seem to indicate, and the result may even be a net reduction in total employment opportunities available in the country.

Even if the net effect of the Green Revolution does not reduce the employment opportunities, the outcome may not be satisfactory.

Almost every developing country will need *increasing employment opportunities within agriculture* for at least the next 25 years in order to keep up with the rising size of its national labor force. No conceivable realizable rate of industrialization can keep up with the total net growth of the labor force in most developing countries at the present time.

Most countries will have to *increase* the number of persons profitably employed *in agriculture* if they are to provide employment for all of their people.

Obviously, all three of these effects just described are highly interrelated: The tendency to increasing size of farms, the tendency toward mechanization, and the impact on employment opportunities.

### INCREASED REGIONAL AND LOCAL DIFFERENCES IN FARM INCOME

The Green Revolution is creating a wider range of farm incomes in each country, both regionally and locally. Where the new technology is available for some crops but not for others, those parts of each country that are suited to the growth of crops for which new technologies are available will tend to forge ahead while other regions will lag behind.

Moreover, coherent, specific programs promising a quick payoff are possible for regions to which the new technology is adapted. For other regions, the most appropriate immediate program is more diffuse and cannot be expected to get results so quickly.

The result is regional resentments, dissatisfaction with the national government, and internal dissensions in governmental agencies.

Even among regions growing the same crop for which new technology is available, differences in farm incomes corresponding to differences in land resources and to differences in the rural infrastructure that is available, tend to increase.

Locally, differences in income tend to develop between owners of land and other farm operators, and also between farmers who differ in managerial ability.

Owners of farms can profit more from a given increase in production

because they do not have to divide the harvest with a landlord, and they generally have greater access to credit.

The task of managing a farm which is heavily dependent on purchased inputs and sells most or all of its products in the market, utilizing considerable amounts of credit in the process, is vastly different from the management of a farm where the skills necessary are those of cultivation.

Farmers vary greatly in their ability to handle these new managerial responsibilities and consequently the new technologies have a tendency to result in much greater differences in income between different farmers, even among those who have the same area of land at their disposal, than existed before.

The important policy questions posed by these increasing differences in farm incomes, both regionally and locally, are not so much problems affecting agricultural growth as they are national problems of social equity and of politicial pressures.

Few governments are, or should be, concerned solely about economic growth. Most of them are also interested in at least a tolerable distribution of income, and every representative government has political pressures to help the poorer people and to aid the less prosperous parts of its country.

The Green Revolution is no more responsible for exacerbating this problem than is every other economic advance that affects particular sectors of an economy but not others.

What the Green Revolution has done is to give rise to these problems *in the countryside* in countries that are predominantly rural and there its effect so far has been to increase the incomes of those already better off in the parts of each country that already were more prosperous. Its effects call for new policy decisions that can make its contributions less localized and less confined to only certain classes of rural people. They call as well for increased attention to nonagricultural solutions to the economic problems of people living in the less advantaged rural areas.

### CHANGED PATTERNS OF INTERNATIONAL TRADE

Next, the Green Revolution is already having a major effect on patterns of international trade. Every developing country is now strongly motivated by a desire for self-sufficiency in every commodity possible, but particularly in every food commodity.

This is an understandable objective, especially in view of the need to conserve foreign exchange for the purchase of industrial equipment and other essential commodities that cannot be produced domestically.

However, to the extent that any country reduces its imports of a particular commodity it reduces some other country's exports. Consequently, every gain made by a particular country in a particular commodity tends to change the pattern of international trade. Each country faces a somewhat different problem at this point.

Much more attention needs to be given to these problems if rising production, particularly of rice in Asia, is not to lead to serious foreign exchange problems among the countries of South and Southeast Asia in the near future.

DANGER OF SUPPLY EXCEEDING ECONOMIC DEMAND

Finally, preoccupation with taking steps to increase production has prevented adequate attention being given to the subsequent problem of assuring an adequate rise in economic demand.

Because a country had been importing large quantities of rice or wheat, and because it was assumed that progress toward getting domestic production up high enough to meet domestic demand would be much slower than it has proved to be, an adequate economic demand was taken for granted.

Now, however, several countries are already at or near the point where additional increases in production may be choked off unless demand increases.

To secure that increase domestically will require either a rise in urban incomes or a lowering of the price of the grain involved, and the latter route would require either consumer price subsidies or lower product prices to farmers.

Lower prices to farmers might or might not inhibit further production increases. The same processes which have led to greatly increased yields can substantially reduce costs of production, depending partly on what price and other policies are adopted.

To get access to foreign markets for a country's "surplus" would, in most cases, require more rigorous grading, more careful handling in storage and shipment, and, in some cases, a shift to other varieties that would be more acceptable to foreign buyers.

Whatever route is taken, the success of the Green Revolution on the production side is leading to difficult policy problems with respect to economic demand.

The significance of each of the six effects discussed in this section is not that these tendencies in all cases represent detrimental developments that should be avoided. They are, instead, effects that have to be taken into account, carefully considered, mitigated where that is considered important, prevented where that seems wise, and allowed to take place unimpeded wherever analysis of the local situation so indicates.

Recognizing what the tendencies are, we need much more careful study in each country to find out what the facts are with respect to each of them and to devise appropriate policy responses. Their net joint effect will be determined by the public policies that are adopted.

There are many important effects of the Green Revolution that are not discussed in this paper. The changes inherent in the new technology modify the pattern of rural living, sometimes drastically; the more continuous care of growing crops throughout the year changes work patterns, social customs and religious observances that mean much to people. They change opportunities for migratory labor on which many people have depended.

The rise of new kinds of commercial and governmental activities in villages causes changes in social structure and status, and gives rise to new kinds of leadership to the detriment of other kinds. The advent of new rural organizations changes patterns of local politics and farmer behavior.

All of these effects are important. They are effects that are not

peculiar to the Green Revolution; they are inherent in many kinds of change.

However, both the suddenness and the pervasiveness of the Green Revolution have, in many regions, precipitated all of them at once, making them especially disruptive and hard to deal with constructively.

## IV. POLICY CONSEQUENCES

While differing sets of local circumstances call for different policies with respect to individual problems, the impact of the Green Revolution to date suggests certain general policy consequences for developed and developing countries alike.

1. Continue the process of the Green Revolution with respect to major cereals and extend it to other farm commodities: Some of the problems we are encountering arise from the fact that high-yielding technology has been developed for only a few farm commodities.

Yet even for those few the process needs to be continued in order to meet new consumer preferences, introduce resistance to aditdional diseases, and fit other sets of local agricultural conditions.

2. Give special attention to the production of fertilizers and other farm inputs, and to the improvement of irrigation facilities: The application of the new technology will be inhibited unless capacity to produce farm inputs is greatly expanded and irrigation facilities improved.

3. Make agribusiness facilities, farm credit, and public services to agriculture available in forms that meet the needs of farms of all sizes: Much of the advantage of larger farms results from their greater access to capital and to facilities and services. Moreover, their advantage is in profits per farm operator rather than in production per acre.

Where population is dense, land scarce, and alternative employment opportunities scarce, greater production per acre may be achieved on the smaller farms if they have access to the facilities they need.

4. Shift from the objective of self-sufficiency in specific commodities to that of creating a modern agriculture: "Self-sufficiency" as it is normally measured never did mean that a country has as much of a particular commodity as its people need.

Instead, it only means that a country is producing at home as much of the commodity as its people are in a position to and willing to buy at the price at which it is offered in the market.

The fact that Pakistan is now self-sufficient in wheat does not mean that there are still not many hungry people in Pakistan. The Philippines can be self-sufficient in rice even while large numbers of its people do not have enough to eat.

Even in the United States with our substantial surpluses and considerable exports we still have many hungry people. Self-sufficiency has served as a useful slogan but it is an ambiguous measure and easily leads us astray.

Instead, the time has come to readjust our priorities in planning for agricultural development in such a way as really to create a modern agriculture in each of a number of countries where a start has been made thanks to the Green Revolution.

A modern agriculture is one that is always changing. It is one that is constantly introducing new technology. It is not commodity specific;

instead, it keeps shifting from one crop to another as relative prices and costs of production change.

It is likely to be one with considerable foreign trade in agricultural products, exporting some of those that it can to advantage and importing others that either cannot be produced domestically or can more profitably be imported.

In order to create a modern agriculture a country must have its own national system of agricultural research that borrows what technology it can from abroad but adapts this to its own peculiar local circumstances and constantly seeks to protect its crops and livestock from pests and diseases.

It must arrange for the importation and/or the domestic production of the farm supplies and equipment needed to put the new technology developed by research into use.

It must develop a rural infrastructure—an "organization of the countryside"—that provides the roads, the outlets for farm supplies and equipment, the markets for farm products, the extension services, the local verification trials, and the farm credit that every farm that is to increase its production needs.

It must have a set of public policies and programs that give farmers a strong economic incentive to produce efficiently.

It must have a program of land improvement, including irrigation where advantageous, to expand and upgrade its agricultural resources.

It must make provision for education and training for the agricultural technicians it needs.

And to create such a modern agriculture as rapidly as possible it is helpful for it to adopt that as a goal, set a target date for its essential completion, and adopt a realistic plan for achieving it.

The time has come to devote more effort to that kind of planning, and less to planning primarily to secure a certain increment in the production of one or a few farm commodities, year by year.

5. Give more attention to overall economic development of specific regions within each country: Each country where the Green Revolution has occurred has some regions within it having *immediate* potential for agricultural growth, and that potential should be exploited.

As a matter of fact, it is only in those countries where the Green Revolution has had an effect so far.

Each country has other regions with a *future* potential for agricultural growth—future either because a new technology for the crops it can grow has not yet been developed, or because it must first have irrigation or physical access to the national economy.

Other 'regions' have *low* potential for agricultural growth even though many farm families may now be living there. Equity and political pressures require that attention be paid to all of these, but the programs that make economic sense in each case are different.

Any effort to bring about agricultural development in these regions with low potential for growth will fail.

In developing appropriate separate plans for each of these kinds of regions, agricultural and industrial planning should be integrated, partly because of the dependence of the growth of agriculture and industry on each other, and partly because some regions are simply not suitable to support a modern agriculture.

6. Revise trade and aid policies of the developed countries to accommodate and facilitate the new situation in the developing countries: Developments growing out of the Green Revolution will affect the trade patterns of all countries, including those of the United States. They will not necessarily reduce our commercial farm exports, but probably will change the composition of them.

Similarly, our aid policies need now to be revised in the light of changed circumstances, and in that revision the foregoing policy consequences should be taken into account.

I have given most of my attention in this paper to the effects of the Green Revolution that confront us with difficult problems. These must concern us.

We must also give increased attention to the problems we face now primarily because the Green Revolution spread so rapidly. But the most important effects are those I listed in the beginning that are unambiguously constructive.

The Green Revolution has shown that there is a solution to agricultural stagnation. It confronts us now with the problems of progressive development. That is a much better set of problems to have.

(Following is a list of selected readings which Dr. Mosher included in his prepared paper:)

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### INTRODUCTION OF DR. CARROLL

Mr. ADAIR. Thank you, Mr. Mosher.

Our first panelist, Thomas F. Carroll, Chief, Agri-Economics Unit, Inter-American Development Bank, and adjunct professor of economics at George Washington University.

A specialist in agricultural economics and rural development, Dr. Carroll received his advanced degrees from Cornell. He has taught economics at UCLA, the University of California, Berkeley, and the University of Chile.

He has also done extensive field work in agricultural economics, including service as FAO regional director for Latin America, 1960–61, and as director, research program in land tenure and agrarian reform, Inter-American Committee of Agricultural Development, 1965–69.

Dr. Carroll has written and lectured frequently on the agricultural problems of Latin America.

## STATEMENT OF THOMAS F. CARROLL, CHIEF, AGRI-ECONOMICS UNIT, INTER-AMERICAN DEVELOPMENT BANK, WASHINGTON, D.C.

Mr. CARROLL. Mr. Chairman, members of the committee, ladies and gentlemen:

Dr. Mosher has performed a brilliant feat in his paper. He has simultaneously demonstrated the interrelatedness of the development process where the successful adoption of any innovation ultimately depends on advances along many fronts, and at the same time he has given vivid proof of Professor Hirschman's thesis on the dynamics of unbalanced growth in which the Green Revolution is a leading edge.

Of the many excellent points raised by Dr. Mosher, I should like to underscore and perhaps elaborate a bit on two issues. Both will be important in considering foreign aid during the seventies.

### THE MIX OF AGRICULTURAL TECHNOLOGY

First, on the mix of agricultural technology. It seems to me that rural modernization is often thought to require the application of expensive machine technology. The success of plant breeding and that of

production systems based on improved seeds show dramatically that this is not necessarily so. Machines may be needed at some further point of the chain of development, but the starting point is a relatively inexpensive biological invention followed by a gradually expanding system of input services.

Dr. Mosher said that the spectacular recent progress in developing of certain food crops has greatly heightened the awareness of the value of biological research. It is hoped that the success in building new, high-yielding varieties of rice and corn can be rapidly extended to other crops and to other crop-animal production systems. Clearly, this awareness had not yet been translated by the international aid-giving agencies into appreciably greater investment programs.

### INCREASING AID FOR AGRI-RESEARCH

National resources allocated for farm-level research are still pitifully small, and the share of external assistance for agricultural research is extremely low.

In the Latin American region, to which my present work is focused, only between 10 and 20 cents per farmer are spent on agricultural research as against 17 cents in Japan, about $5 in Western Europe, and $46 in the United States. During the past 8 years less than 1 percent of all external aid flowing to that region was for agricultural research.

It is, of course, true that it is not only the amount of money that counts, as relatively small amounts of funds if systematically and carefully applied to key problems over a number of years can produce exceptionally high returns. In this respect the lesson of the Green Revolution is that investments in technological innovations need to be accompanied by long-term commitments and continuity of programs. A closer identification is also needed between the international scientific community and national goals and institutions. Few foreign aid programs now have these characteristics.

While much more must be done in biological and adaptive technology, the serious policy problems mentioned by Dr. Mosher, which now emerge in the wake of the Green Revolution in Asia, point out serious inadequacies of research and development in other fields, especially related to social sciences.

### NEED FOR SOCIAL SCIENCE RESEARCH

We have made much too little progress in social science research in devising viable institutions and services especially for farm credit, marketing, extension, management and agro-industrial assistance, so that the spectacular new production possibilities could be fully and rapidly used.

Much of this need is in the realm of "software technology" rather than hardware technology. These aspects of the technological complex are clearly more difficult and controversial than physical and biological work. They mean not only new tools but also new organizational patterns, new forms of decisionmaking and organizational behavior, all of which may run counter to local social and power relationships. Yet, the Green Revolution offers a great opportunity to overcome these resistances. As soon as new, attractive production possibilities

are available, the basic limiting factor to agricultural development in most areas becomes not so much the lack of physical facilities—brick-and-mortar-type investments—but a shortage of trained manpower and organizational ability needed for program operation.

More attention will therefore be required to investments in extension facilities, management training, and other institutional and organizational infrastructure, to complement biological research and the more traditional forms of physical infrastructure.

### THE ISSUE OF EMPLOYMENT

My second point is on the important issue of employment, mentioned not only by Dr. Mosher but also by Secretary Freeman.

There is a real danger, indeed, that in the absence of farsighted policies to complement the new technologies sparked by the Green Revolution, rural employment problems and its counterpart, income distribution problems, may become more serious. In Latin America, this could increase the potential for rural unrest. Let me illustrate the existing employment crisis. Recent estimates put the number of unemployed in Latin American rural areas at some 10 million persons of working age, or about one-third of the economically active population in the agricultural sector.

In spite of the fact that the agricultural sector which made up about 54 percent of the total employment in 1950 has fallen to about 45 percent in 1968, the number of people in the farmwork force during the 1960's increased by about a half million per year. Migration to the cities has accelerated sharply, but not enough to offset the increase in rural population. At present rates of growth, and assuming the upward trend in rural outmigration to continue, about one-third of the net increase in population will remain in agriculture during the next decade or two.

This means that the total rural work force in Latin America will grow by about 1 million workers annually. Urban employment opportunities are not expanding rapidly enough to provide productive jobs for the stream of urban migrants, nor are services expanding sufficiently. Could the Green Revolution provide more jobs and increase peasant incomes?

### CONSEQUENCES OF APPLIED FARM TECHNOLOGY

There is no question that increased yields and a better balance between food production and nonfood exports can be highly beneficial to rural Latin America. Yet, if there is no change in the prevailing inequitable agrarian structure, the Green Revolution may primarily benefit the largest and wealthiest farmers with good resources and access to markets. It might make the rich still richer and enable them to capture markets previously served by smaller, semisubsistence producers.

Modernization on large farms using labor-replacing technology may yield increases in output of some crops, and the earnings of the estate owners will increase.

But it may reduce rural employment opportunities and increase the burden of the disadvantaged who will have to join the ranks of the

landless, become migrant workers, or swell the unemployed in the cities.

Thus, in the absence of reform programs, progressive taxation, and unless the new technologies are carefully adapted to the average rather than the exceptional farmer's needs, the employment and income distribution problems mentioned could become even worse and aggravate social tensions.

### TWO STRATEGIES OF DEVELOPMENT

In the concluding section of my comment, I would like to give you rapidly two examples of possible strategies which could take advantage of the new biological techniques without deleterious effects on farm employment. Fortunately, the seed/fertilizer revolution does not require large farms; small family-size units can also benefit from it.

The best hope for providing more employment through the Green Revolution lies in strategies which stress small farm development and wider participation of rural people in the development process.

Economies of scale can be obtained in such situations, not by increasing farm size, but by providing larger input, marketing, processing and other services.

The Green Revolution is a serious challenge to find optimal combinations between output increasing and equity promoting programs. Acceleration of agrarian reform has become more urgent. But other imaginative strategies are also needed to help peasant cultivators benefit properly.

### I. DECENTRALIZED AGRO-INDUSTRIAL DEVELOPMENT

One of the examples is decentralized agro-industrial development. In essence, this calls for an interlocking system of investments in rural areas which could create conditions for self-sustained growth. The income generation and employment potential of decentralized agro-industrial systems based on the new production possibilities should be more fully realized.

Such systems can take advantage of important economies of scale and through complementary investments create the conditions for fuller use of local natural and human resources.

The establishment of decentralized agro-industrial centers within the rural environment, with close linkages to farm production, appears to be a promising way of extending the level of rural income and employment opportunities. Greater attention is needed for development of agro-industrial projects in which processing, storage, and transport are an integral part of the production system. The location of food processing and other agro-linked industry can be brought closer to their sources of supply and their clients. They would reduce the concentration of industrial activities in the large urban centers and expand economic activities generally in interior areas.

Decentralized fertilizer manufacturing and mixing, which takes advantage of new hydroelectric power sources, appears to have a great potential. Demand for fertilizers is growing and the income elasticity of demand for fertilizer is high even at modest income levels. More

decentralized processing and light manufacturing based on agricultural livestock and forest products should also be considered. Shorter transport routes for inputs and outputs would lower prices and thus assist in broadening the market for farm products.

It is also plausible that a number of isolated and incremental investments which at present appear uneconomic can be shown to be viable by carefully linking them to parallel investments which jointly permit economies of scale and self-generating growth in a regional context. This approach makes a great deal of sense for smaller market towns and strategically located population centers whose influence can radiate throughout rural areas.

This decentralized agro-industrial strategy would mean shifting emphasis away from the few major urban centers toward a number of serving rural areas. At the same time it implies convergence of investments around the number of "growth poles." The case for integrated agro-industrial planning rests on a geographic complementary of investments. When applied simultaneously and in the proper sequence, the investments yield a greater output than if applied separately and discontinuously. It is different from the usual pilot or demonstration project in that it must be large and dynamic enough to become self-sustained and to radiate its influence to a large hinterland.

### II. DEVELOPMENT OF COOPERATIVES

The other example I have chosen is in the field of cooperative development. One of the most promising forms of rural organization through which employment and income goals can be reconciled with technological and productivity considerations is the farm cooperative.

I suggest that the potential advantages of cooperatives and quasi-cooperatives can be more fully explored and used in future development strategies.

Cooperatives can be strategic in a variety of situations, e.g., where relatively small operating units need to be combined with large service units providing inputs. The always scarce managerial talent and heavy equipment can be concentrated in the cooperative, thus realizing economies of scale. When it is possible to reduce costs and gain better product distribution by joint handling of storage, transport, processing, and other aspects of the marketing system, cooperatives can be easily justified. Cooperatives have also proved themselves in situations where credit extension and other educational services can be more effectively performed on a group basis.

The rural cooperative movement in Latin America is still in its infancy. Efforts to transplant cooperative ideas from other regions have often failed, but promising experiences with community and group management are available, especially in areas where the agrarian structure is more egalitarian and in connection with land reform programs. In areas of irrigation, pioneer tropical settlement, or complex machine services, group control is often a necessity, so that peasants must and do organize effectively to operate indivisible resources.

In general, it seems that market-oriented cooperatives have the best chance where peasants are already organized into unions and where

they have been exposed to community development or self-help programs. Successful continuation of initial group activity on the local level also depends on the emergence of second-level federations or higher level groupings with linkages into the wider reaches of the agricultural supply and market system.

All these experiences should be carefully evaluated and taken into account in designing future investment project. The Green Revolution is an opportunity for the introduction and strengthening of novel forms of cooperatively based rural development projects which have the capability of involving large numbers of campesinos and assuring their wider participation in the benefits of the development process.

SUMMARY OF MAJOR POINTS

Let me summarize my major points:

1. Investments in biological and adoptive research along with its corollary of educational services should be greatly stepped up and put on a more sustained basis to cover the major ecological regions.

2. Research and development in rural organization, institutional innovations, and management systems must complement work in the biological and hardware technology fields.

3. The new food grain techniques present an extremely favorable opportunity for development which simultaneously increases output and provides a wider distribution of income and employment. However, this calls for special and, in some areas, controversial and politically sensitive strategies. Small farms, bolstered by large services, have a special role to play in employment and income-oriented policies.

4. Decentralized agro-industrial complexes and rapid multiplication of cooperatives and other locally based peasant associations offer great hope that the new biological advances can be an opening wedge to broad-gaged, human-oriented rural progress.

Thank you, Mr. Chairman.

Mr. ADAIR. Thank you, Mr. Carroll.

INTRODUCTION OF DR. LEWIS

Our next panelist will be Dr. John P. Lewis, dean of Princeton University's Woodrow Wilson School of Public Affairs, and the U.S. aid mission to India from 1964 to 1965. A specialist in economy in government, Dr. Lewis received his Ph. D. from Harvard in 1950.

Following his graduation, he became a staff aide to the Council of Economic Adviser's but returned to teaching at the University of Indiana in 1953.

From 1961 to 1963, he was chairman of the department of business economics and public policy in Indiana's Graduate School of Business.

He was appointed a member of the Council of Economic Advisers by President Kennedy in early 1963, and served until the fall of 1964 when he undertook the job as director of the AID program in India. He served there until earlier this year when he was named to his present position.

Author of "Quiet Crisis in India" in 1962, Dr. Lewis has written frequently on economic development and planning.

## STATEMENT OF JOHN P. LEWIS, DEAN, THE WOODROW WILSON SCHOOL, PRINCETON UNIVERSITY, PRINCETON, N.J.

Mr. LEWIS. Thank you very much, Mr. Adair.

Mr. Chairman, members of the committee, ladies and gentlemen: I am going to confine myself to the Indian case for one thing because I know more about it, another reason being that this one country, which, as you know, accounts for more than a third of all of the people in the developing countries with which we do now have contact, leaving aside, of course, the enormous one that you mentioned in your question, Mr. Chairman, is intrinsically very important.

### THE CASE OF INDIA

I find that Dr. Mosher's very, very good paper is a very good general analysis of the Indian case.

It certainly is true for India, as Bill Gaud has said, that the breakthrough in food grains production in the past 3 or 4 years, deserves the label of a revolution. It is not only the most hopeful thing that has happened, I think, in the Indian economy since they began their concerted development effort back at the start of the 1950's, but I think the most important thing.

I think that it is responsible, although I shall be trying to surround this with some caveats as I go along, and although I am very, very mindful of Secretary Hardin's warnings against forecasts—I am an old and battered forecaster myself—I think it is as responsible as one can be in these things to say that what has happened in India, Indian agriculture, seems to have turned the growth trend.

Of course, you know the trend is a very slippery thing in agriculture because of the weather. I also would underscore the caveats about bad monsoons that have been registered by others this morning.

I think you can say that the trend has been shifted from a growth of about 2½ percent annually in agricultural production from 1950 to 1965 to something in the neighborhood of 5 percent a year, and that this will continue for a while.

I may say a little bit more later about this matter of duration.

### A PROFOUND CHANGE IN INDIAN DEVELOPMENT

If this is so, this is really a profound change in the whole texture and hopefulness of the Indian development situation, because it means, of course, in the first place, that the total growth of the economy can be raised appreciably. I think it means that it is now physically feasible, administratively feasible, for the per capita growth for the economy as a whole to go up to something like 3 percent annually. It means that food grains production, which had in the past just barely kept pace with the growth in population and, with rising demand, had resulted in a widening gap between demand and supply, now can rise for a while significantly faster than population growth and overtake demand.

As I read through Dr. Mosher's paper, in its early portion where it touches on, really, the subject of the preceding session, referring to matters of causation and explanation for what has happened,

I was moved to want to amplify the paper a little bit as I thought of the India case. I was further moved to do so in, I hope, not a too parochial way by Congressman Findley's question. But I think that this subject has really been very well dealt with by the discussion as a whole.

I would just emphasize that in the Indian case—although the new varieties certainly are absolutely an essential element in the new technology, and although the new technology is an absolutely indispensable ingredient in what has happened (you really have to have something to peddle before you can get much response)—it is also true that this Green Revolution is an enormously complex phenomenon with a great many variables there. Along with the technology you do have to have the inputs. There does have to be fertilizer or the seeds don't work. There has to be water. And there also has to be some motivation and organization in the process.

### INDIAN SELF-HELP EFFORT

As Dr. Mosher's paper indicates, this has taken a form, and it has taken the form in India, of an increased accent on incentives. The reliability of prices for giving rewarding returns to farmers has been established. I emphasize also that in the Indian case, while those of us who were involved as kibitzers and aiders and abetters did play some role, this was very much an India show. Going back to times when it looked as if the fruitfulness of efforts to build an infrastructure of extension and so on was somewhat in doubt, there has been a long and quite sustained, fairly serious effort on the part of the Government of India to do something about agriculture.

Laterally, the change of course that has been achieved in the past 5 years involved a quite self-conscious, quite deliberate and almost dateable change of policy.

That would be my third point in talking about what has happened—that not only has the change been complex, and not only has it been in considerable part an Indian effort, but, in addition to the technical side of things, it has been very much a policy phenomenon—the result of deliberately taken policy decisions. There were a set of policies adopted by the Indians in the years 1964 through 1966, particularly, that were instrumental to what has since happened.

Finally, in this introductory portion of my remarks, I would say that in assessing the influence of outsiders, one must also take considerable account, as has already been suggested generally, of the efforts that the U.S. Government and other aiding parties like the World Bank have made toward constructively influencing Indian policies through their provision of "big ticket" aid—through the manner in which program assistance and in which Public Law 480 was given, particularly beginning about the middle 1960's.

### PROBLEM OF "BOTTLENECK FACTORS"

With respect to Dr. Mosher's paper, let me also say a word about his second set of points, about the effects of the Green Revolution that reveal deficiencies—in other words, about the point that, as you get

something going that seems to pivot around seeds, fertilizer, assured water, and incentives, and as agriculture becomes profitable and starts moving, you run into a whole lot of lagging bottleneck factors that have to be dealt with in a reasonably timely way if things are not to be derailed. I thoroughly agree with this as it applies to India. There are many such bottlenecks, many such lagging areas.

I put a little bit different gloss on it, however. Here Dr. Carroll has anticipated me by referring to Professor Hirschman. He, I think, taught many of us to realize that this is the way you expect successful development to happen. When it succeeds, you get a thrust, one sector moves ahead; and it begins to create effective pulls on the laggards. It begins to make it possible to break down these bottlenecks.

### BREAKING DOWN BOTTLENECKS

What I regard as the most encouraging thing, really, about the Green Revolution in India is that these effective pulls indeed are being generated quite conspicuously, and already with a great many results.

Mr. Dennison, who is going to be heard from this afternoon, is associated with the foreign company that pioneered in Indian fertilizer investments, an American company. It had a pretty rough road to go. The road of subsequent companies has not been easy. But fertilizer production, though it is not coming up as fast as many of us would like to see, is indeed coming up very, very rapidly by any sort of absolute standard.

Agricultural credit is indeed being supplied in much more effective and much more extensive scales.

I have been very pleased at the movement on the water front. Water has been very effectively developed by the private sector through private tube wells, in recent years going in at a great rate, and, moreover, the Government of India is becoming much more focused, I think, in its efforts to develop a general water strategy. I think there is some pull already on the potential bottleneck of rural roads, although not nearly enough.

The pulls are being generated, and the, perhaps underlying, consideration is that the success of the Green Revolution is conspicuously enough and widely enough realized so that agriculture has indeed become the top priority subject in the country politically. There has been a farm bloc formed. We may say this is not entirely for the good, but the fact is that Indian farmers have discovered that they know what they want and through at least regional kinds of organizations they have learned that they can lean on administrators and politicians and get some results. They became quite specific and quite competent, I think, as a pressure group.

In saying this kind of thing I always feel very, very uneasy, because I couldn't agree more passionately, really, with the notion that the last thing that this situation needs is complacency. These are all beginnings. They could very well be derailed.

They could be derailed by a change of heart on the part of the Indians, though, as I say, I think the political current now is moving in the right direction. The process certainly could be derailed by fumbles that could be made from outside. If the fertilizer in heavy

fertilizer imports still required were not fundable, then this could certainly block matters.

But I think that the process that is underway, taken together with the fact that the Green Revolution indeed has a long way to spread yet, and taken together with the fact that there is a good deal of momentum in India in the development and improvement of technology warrants some confidence about the staying power of the Green Revolution. Again I agree emphatically about applied research, but perhaps in this country more than some others that we are considering there has been an establishment of applied research activities that are more abundantly, although not sufficiently, funded. And, partly through the help of outsiders, they are better focused in their efforts than was the case some time ago.

All of this makes me think that there is here a potential for momentum for some years to come in the 1970's.

### SOCIAL STRESSES AND INEQUITIES

Let me turn quickly to this matter of the impact of all of this on social stresses and inequities. I am going to try to confine myself to very limited comments, and this is very hard because I am in the midst of trying to write a book which deals in part with this subject, and it is the worst time to ask a fellow to summarize his thinking in 5 minutes. But I will try only to make three points.

The first is that the last thing anybody concerned with social inequities and political stresses in India should do in the context of the Green Revolution is to ease up on the agricultural push, itself.

This is the thing that is providing the new growth dynamic to the Indian economy, and the only effective way of contending with social inequities in an economy this poor in general.

The main problem of inequity in India has been accumulating for a long time, at least since the beginning of the development effort, and that is simply that there are enormous numbers of leftover people who have not had a chance to participate in the development process, because it hasn't been going fast enough to provide them with tools, jobs, or real increases in incomes.

The chances of doing something about that are enormously better in the context of 3 percent per capital growth than in 1 percent per capital growth.

So I thoroughly agree with Dr. Mosher's paper as it applies to India on this count.

### INDIA: FESTERING PROBLEM OF ECONOMIC INJUSTICE

In the second place, however, I do conclude that in India there is a festering, potentially explosive problem of economic injustice, and it is indeed being, in a certain sense, aggravated by the Green Revolution, itself. Much of this, as I just suggested, is a cumulative problem, built up out of insufficient gains in the past, and the patience of the system in any case would be tending to wear thin.

Some of the old tranquilizers, the Nehru image, the glamor of the independence movement have, of course, progressively worn off. But in addition, as Dr. Mosher points out, the Green Revolution does

bring a sharper confrontation of progress and despair in the countryside, itself.

In the past, the countryside was sort of uniformly backward and you only got the spinoff of this problem as people migrated to the cities.

Now you do have really successful, profitable agriculture going on side by side with some very disadvantaged people.

I want to try and make this point carefully, because it is a tricky one, and because by no means are all of the returns on it in. I am pleased to report to you that there has been a lot of analysis and thinking going on about this problem in India, particularly in Delhi, as far as I know—in the Government of India, in private groups, and in the AID mission now for perhaps 18 or 24 months.

## GREEN REVOLUTION EFFECTS ON FARM CLASSES

My own tentative conclusions are that the technology of the Green Revolution is not particularly skewed against the little farmer, is not particularly skewed, let us say, in favor of the big farmer, though he has earlier access to information about it, and does have greater access to capital, including borrowed capital.

It does extend to what we would think of as a very small farmer, let us say with irrigated land about 2 acres, running up to 15 or 20 acres, this chap at the moment is prospering as he takes up the new varieties. He has overextended in terms of his credit position. He is catching on a little bit later on. Thus he would be particularly vulnerable to a breakdown in incentive prices. But he is probably going to make it in good style, and he identifies pretty much with the larger farmer.

The people who are disadvantaged are, first, the dryland farmers. There is a much bigger difference between the dry and wetland farmer than between big and little. The Green Revolution has not extended very much to the majority of farmers, who are dryland farmers.

Second, what I call the minifarmers, these people that have such small holdings that after they take care of their own subsistence they are simply not at the scale where they can buy the inputs even if they know about them. I don't know exactly what the cut-off is. I suppose with irrigated land it may be less than an acre. With dry land it is considerably more. These people, however, are destined to be left behind by this kind of agriculture.

Third, the tenants. The tenants, I think, may become a diminishing breed as they get squeezed out gradually by landlords reclaiming their holdings because agriculture has become profitable. The tenants, therefore, will join the final group, which is the largest and the most serious in its plight, and those are the agricultural laborers.

## EFFECTS ON EMPLOYMENT

This brings to the matter of employment, the employment effects of the Green Revolution. It is perfectly true, or seems to be perfectly true, that the early effects have been to increase employment. This is because production has gone up so very fast that although output per worker has been rising with the new technology, total production has been rising enough to increase the total use of labor.

This has been particularly, I think, because of double and triple cropping, as you extend irrigation, particularly, with tube wells.

In the longer run, my own unhappy conclusion is that the agricultural labor market is going to be very soft because of the natural increase in supply, the additional flows, as I suggested, of the minifarmers and the dispossessed tenants, people reclaiming their land, and because there will be some continuing mechanization.

I sympathize a lot with the things that have been said against mechanization here, but, you know, one of the great policy changes, styles, that the Indians have made in the process of achieving this change has been a greater disposition to leave things to the market to organize, and to recognize the importance of incentives, the need for agriculture to be a profitable industry.

Therefore, it seems to me that they are likly to be rather reluctant to attempt, and they also may think it is not politically or administratively feasible, to interpose much in the way of controls or prohibitions on mechanization.

I would hope, myself, that they will use some graduated taxes, excise taxes, on particularly labor displacing mechanization, but I think that mechanization will probably be used where there are bottlenecks in the labor supply, particularly at harvest time, and, therefore, that the outlook for the labor market is a soft market.

Indian farmers are not going to prove to be any more philanthropic as wage bargainers than any farmers anywhere in the world.

This leaves you with the prospect of considerable stress—a sort of populist protest—pressure, in the countryside for the decade coming that is rather alarming.

### A PUBLIC WORKS CONSTRUCTION PROGRAM

My final point is that, in a sense, what to do about this is perfectly well known. It has been written about and talked about for a long time.

There are, to be sure, some other things you can do. Organized industry is not going to provide a great part of the increased employment. I have great sympathy with the growth center proposition that Dr. Carroll has mentioned. But the increments and direct employment you can get from that are somewhat limited, I think. I don't think that you can prohibit mechanization completely.

The answer is a very, very ambiguous construction program that happily can be for things that are enormously needed, that have very high benefit-cost ratios and that have been accumulating for a long time—all kinds of construction of farm to market roads, of ditches, drains, of the infrastructure for these decentralized growth centers that Dr. Carroll mentioned, of urban redevelopment because the people in the cities are already there and have an urgent need for services.

There are almost endless, high payoff things that can be done with a labor intensive public construction program. The Green Revolution creates, in one sense, an enormous opportunity to do this because the thing that has blocked it in the past has primarily been food shortage. With food in short supply, when you begin to increase employment and incomes you get skyrocketing food prices. This is the last thing that you can stand politically in India.

Now with food becoming increasingly abundant, you have the food resources to, if you will, finance this kind of thing.

But there is just one big catch, one big hangup. That is that even

though this is labor intensive, you are going indirectly to generate considerably increased requirements for imports, for other kinds of consumption, and for the investment goods to service the increased consumption needs of the increased employment generating increased incomes.

You are back to the question then of what is the limit, really, of the foreign exchange availability that this country can plan for.

On that question, I don't claim to be able to forecast at all. Mr. Chairman, I will be happy to turn it back to the committee.

NEED FOR FOREIGN EXCHANGE

I would say in conclusion that if this analysis is right, I don't want you to feel that the Green Revolution in India simply means that you eliminate the need for Public Law 480 assistance, which in a certain sense is politically easier to get, and replace it with a need for more dollar assistance, which is harder to get.

The latter is a limited need in terms of time, and it means that you are talking about a wholly different order of possible success.

But there is this foreign exchange bottleneck that, it seems to me, casts a threatening cloud over the basic answer to what seems to me to be the somewhat ominous byproduct effects of the Green Revolution, excellent as that is.

Thank you.

Mr. ADAIR. Thank you, Dr. Lewis.

INTRODUCTION OF DR. MELLOR

Our final panelist at this session is John W. Mellor, professor of agricultural economics at Cornell and a specialist in the role of agriculture in economic development.

A graduate of Cornell, Dr. Mellor has taught there since 1952 and became a full professor in 1961. He has been an associate director and director of the Center for International Studies at the university, and spent 1963 and 1964 at the Indian Agricultural Resources Institute, New Delhi, as a visiting professor.

## STATEMENT OF JOHN W. MELLOR, PROFESSOR OF AGRICULTURAL ECONOMICS, CORNELL UNIVERSITY, ITHACA, N.Y.

Mr. MELLOR. The new high yielding varieties of grain and the related institutional developments have substantially increased the rate of growth of agricultural production. This means of economic growth has particularly desirable equity effects, since it increases the supplies of those commodities which are most important in the consumption patterns of the lower income persons in society. However, the benefits to lower income persons may be lost without appropriate public policy.

Very few persons or groups are absolutely worse off as a direct result of widespread application of the high yielding varieties of grains. There is, however, a substantial widening of disparities in income—many of the already well-off having larger absolute and percentage increases in their real incomes than the lowest income groups. In addition, indirect price and employment factors may result in actual reduction in incomes for a few regions and groups.

There are two basic concerns with respect to the new high yielding varieties of grains. First, and most important, how to maintain the accelerated rate of production growth with its requirement of a steady stream of new research results and rapid acceptance and broad diffusion of those results. Second, how to minimize the widening of income disparities both among socioeconomic groups within regions and among regions. I discuss below six areas within which policy can act to narrow income disparities and at the same time foster the production increases associated with the high yielding variety programs.

### INCREASING EMPLOYMENT

1. Increasing employment: The most disadvantaged group in most low-income countries is the landless labor class. The means of their improvement is expanded employment. Accelerated growth in food supplies associated with high yielding varieties makes it possible to follow policies for expanding employment.

First, there can be more emphasis on rural public works programs, such as roads, schools, power distribution lines, and irrigation and land improvements. These programs become possible because of the enlarged food supplies for absorbing the increased purchasing power which goes with the greater employment. The returns to these works becomes greater because of the higher degree of commercialization of farming associated with the high yielding variety programs. Likewise, expanding demand for foods through such employment programs is the most useful and effective means of supporting prices for an expanded food supply. Similarly, concessionary imports of food through Public Law 480 can continue a useful role even without the context of rapidly rising production if demand is expanded commensurably with the supply, through employment programs.

Second, the structure of the industrial sector of the economy can be shifted toward consumer goods industries which provide more employment with the given limited stocks of capital. This, again, is possible because the food is there to take care of the increased purchasing power accompanying expanded employment and because the higher incomes of farmers greatly expand the demand for such products.

### INCREASING FARM PRODUCTION

2. Increasing the intensity of agricultural production: One of the most suitable ways for increasing employment in agriculture is through increased intensity of production. The new high yielding varieties themselves increase intensity directly by requiring more inputs, including labor, in the production of a greatly increased output. They also lend themselves, through their potential for shorter growing periods, to more double and triple cropping.

More important, the increased income associated with the high yielding varieties greatly expands the demand for livestock commodities, such as milk, and fruits and vegetables, all of which provide greater farm employment per acre of land. Increasingly, we can think of agriculture as much more than a producer of calories for sustaining the bare minimum of human life.

A number of policies are needed to encourage the increased intensity of farming which the high yielding varieties facilitate. Many of the more appropriate commodities are perishable and provide complex marketing problems. There is a need for research on how to increase the yields and improve the production practices for such commodities. The quantity of purchased inputs required for intensive farming is large and requires larger and more complex credit programs. Programs to aid the small farmer must be based on economic analysis of these problems and potentials.

BROADENING BASE OF LAND OWNERSHIP

3. Broadening the base of land ownership: Particularly where the new high yielding varieties of crops have been applied during periods of relatively high agricultural prices, there has been a tendency for increased concentration in the ownership and operation of land. There has been purchase of land by those with already relatively large holdings and tendency for owners of land to resume cultivation and to displace tenants. These actions widen income disparities. More important, with land in larger holdings the amount of hired labor needed to farm with intensive cropping systems becomes very large. In farming, large labor forces are almost always expensive, because of difficult management problems, no matter how little the labor is paid directly. Thus, once one gets relatively large farms one faces the dilemma of either not intensifying production and therefore having a slower rate of growth of production or introducing mechanization which may cause a net displacement of labor. With very small farms, as in Japan and Taiwan, extremely high levels of cropping intensity, crop yields, and rate of growth of production and incomes were achieved prior to much mechanization. Thus, particularly in the face of the new technological possibilities in agriculture a broader base of land ownership may be necessary to prevent premature mechanization and consequent increased income disparities.

PRICE POLICY

4. Price policy: The new high yielding varieties of crops result in greater production and substantially reduced per unit cost of production. Sharply expanded production of the basic grain crops will naturally bring about a reduction in their prices. Such price reductions will facilitate the development of nonfarm employment opportunities and the transfer of farm resources to types of commodities such as livestock products, fruits and vegetables which provide increased employment and for which demand is highly elastic. Success in preventing such price declines in effect transfers income from the poorer urban and rural classes to the wealthier rural classes.

Price stabilization programs which prevent sharp fluctuations in prices may facilitate further production increase. Such programs need not provide higher average prices. However, increasingly well organized commercial farm groups may succeed in using a price stabilization mechanism to obtain income transfers to themselves.

AVAILABILITY OF PURCHASED INPUTS

5. Ready availability of purchased inputs: The high yielding varieties are improvements over old varieties primarily because they are much more responsive to high rates of utilization of inputs such as fertilizer. If the inputs are not available, the benefits are not received. In a situation of scarcity, cultivators with small holdings and with consequently less economic, political, and social power are least likely to obtain the inputs. This is likely to prevail even if there are special programs for small farmers. Under such circumstances the high yielding varieties can lead to further unnecessary widening of income disparities.

Both from the point of view of accelerating overall rates of production growth and from the point of view of helping the small cultivator the most useful means of dealing with this problem is by making inputs abundantly available. With an easy supply situation small cultivators will normally obtain ample supplies. Even in the case of lumpy capital investments, as for private, electrically driven wells and in some cases tractor services, the small cultivator will be better served by an abundant supply of these capital items and consequent contract hiring of services to those with small holdings.

INFRASTRUCTURE INVESTMENT IN BACKWARD REGIONS

6. Infrastructure investment in backward regions: Regional disparities in income are likely to be widened by the new high-yielding varieties. This is because these varieties tend to respond most vigorously under the already most favorable natural conditions and where past investments in infrastructure have been most substantial. Thus regional income disparities tend to be cumulative as the already prosperous areas obtain a better response from the high-yielding varities which in turn gives the higher incomes and the larger tax base for financing more infrastructure investment in those same areas. Both for maintaining rapid growth rates and for minimizing regional disparities in income it is desirable to make capital investments in research facilities, education, transportation, irrigation, power, administrative structures and so forth, in those regions which are currently backward but in which such investment will pay off in the long run. Careful study is of course needed to avoid such investment in situations without long-term potential.

Mr. ZABLOCKI. I am sure you would all agree that the presentations heard and the discussions in our first session were very fine.

So, too, in the second session, Dr. Mosher and his panelists, Dr. Carroll, Dr. Lewis, and Dr. Mellor, deserve a hand of applause-and-appreciation. [Applause.]

The questions to the second session will be asked in the afternoon, when we hopefully will resume the symposium at 2 o'clock.

Without objection from any of the members of the committee, I would like to invite the questions to the second panel from the observers, the audience, first.

That will reverse the order, so to speak. Members of Congress can ask their questions later, if they have questions.

I know there are many of you who have questions. Undoubtedly, many of you will present your statements and writings by December 19, so that they may be included in the symposium record.

The symposium will now recess until 2 o'clock.

(Whereupon, at 1 p.m., the subcommittee recessed, to reconvene at 2 p.m. the same day.)

AFTER RECESS

(The subcommittee reconvened at 2 p.m., Hon. Clement J. Zablocki (chairman of the subcommittee) presiding.)

Mr. ZABLOCKI. We are ready to resume the symposium hearing. As has been announced earlier we will invite questions from the observers and then from the panelists or Members of Congress.

I would like to announce that after about approximately a half hour question period devoted to session No. 2, the third session will begin approximately at 2:30 or 2:45 p.m.

At the conclusion of the third session, there will be a showing of a prize-winning film, "A Future for Ram" depicting effects of the Green Revolution on a single family in India.

The length of the color film is approximately 25 minutes. Those who have seen it or those who have other commitments need not stay for the film. But we do hope those who are able to would remain after the conclusion of the third session to see this very effective and inspiring film.

Now we will welcome and invite questions from observers, if any, to Dr. Mosher and the panelists, Dr. Thomas F. Carroll, and Dr. John F. Lewis, and Dr. John W. Mellor, or if there any questions to anyone at the dais, we will entertain the questions from the floor.

Does anyone have a question, please?

PROBLEMS OF AGRICULTURAL CHEMICALS

Mr. LANDSBERG. My name is Hans Landsberg, from Resources for the Future. I am wondering, I don't know who to address this to on the panel, but is there any possibility that there is rising concern over the adverse effects on the environment of agricultural chemicals of all kinds, particularly the ones that transcend into national boundaries?

In the perhaps immediate but in the more distant future—I don't mean 10 years, but 3 or 4 years, there is present a threat or interference of the Green Revolution in the developing countries. I am asking this question, because I see a great rising emotional wave here that could easily spill over from what is going on in this country to other countries, and yet in any other country the cost-benefit relationship might be quite different.

The lay of the land might be quite different. The kind of chemicals might be different. But I don't find then it is impossible to envision some new difficulties here. I am wondering whether anybody on the panel has some assessment of this.

Mr. ZABLOCKI. Dr. Myers?

Mr. MYERS. There is no doubt that there has been a great wave, as you suggest, of concern about what the persistent pesticides are doing

to the environment. There is also no doubt in my mind that this is a legitimate concern. Yet, we have to balance this concern against the good that comes from use of pesticides.

There is no viable alternative now to chemical pesticides for the control of many, I think one could say most, of the important pests of man and his crops and his domestic animals. Chemical pesticides will almost certainly have to continue to be used, if we are to sustain the advances in agriculture we already have, and to continue to expand production.

As we increase the intensity of production and cropping, using of improved varieties which occupy large areas of land, add fertilizers to get more vigorous growth, and so forth, we tend to accentuate the damage that can be done by pests.

So, as I say, I see no alternative but to continue to use the chemical pesticides. Hopefully, over the next few years, we will be developing fairly rapidly more highly specific pesticides with a more rapid or at least more nearly controllable degradability so that the adverse effects on the environment can be reduced.

Personally, I do not foresee the likelihood of extensive banning of the use of the chemical pesticides, even the persistent ones, either in the United States or abroad, until alternative pest control methods are available.

I believe that the efforts to ban use of DDT in certain areas would not have succeeded had there not been viable alternatives in terms of less persistent insecticides to control the same insects that DDT was being used to control.

It is a threat to the Green Revolution—this concern about the pesticides and it is a legitimate concern. I frankly cannot believe, however, that we will reduce millions and millions of people into starvation by the banning of the use of pesticides.

Mr. ZABLOCKI. Yes, Madam.

### PRICE AND INCOME UNCERTAINTY

Dr. NELSON. My name is Louise Nelson, Davidson College. I would like to ask Dr. Hardin if he would expand or elaborate a little on a point he made this morning with respect to diminishing price uncertainty, income uncertainty.

Dr. HARDIN. The techniques that have been used have been largely price supports at a minimal level, while at the same time, working at the factor product price relationships. It is not the absolute price that we are so much concerned about as it is the spread.

As Dr. Mellor and others have pointed out, you are in real danger when you start subsidizing inputs. Artificial rather than enduring incentives may be established. But I for one believe that then it makes more sense to go that route than it does to establish unreasonably high levels of product price supports.

If we move to improve the technology of factor production and distribution, we have an opportunity to reduce the real cost of the purchased inputs over time. By gradually removing the subsidies as real costs, fall due to the improved technology, farmers pay, more and more of the total cost, the subsidy drops out, and ideally the factor price does not rise.

Factor-product price relationships are of critical importance. This past month, for example, at the farm level about 8 pounds of corn were required to buy 1 pound of nitrogen in Argentina. Similar relationships existed in the interior of Brazil.

In contrast, U.S. Corn Belt farmers last year bought a pound of nitrogen with about 2½ pounds of corn.

Some nations are in difficulty because they supported wheat or rice at too high a price. But as a trade-off, they got their production programs moving.

May I add one other point. Generally speaking, the weather uncertainly is somewhat reduced as we move into and use more advanced technology.

So we're working on uncertainty from the biological as well as from the economic viewpoint.

EFFORT IN LATIN AMERICA

Mr. TYLER. I am Curt Tyler of International Basic Economy Corp., and I would like to ask a question of Dr. Mosher on the idea that a system one could call modern agriculture could be an integrated answer, and speaking just to Latin America for the moment, giving consideration to the participation already existing and the proven benefits that the foundations have brought and that AID has brought, concern of our own Government expressed here today, the reference earlier to FAO. I am sure curious as to what role perhaps the OAS or the governments of our neighbors to the south of us should be playing or are playing in the deliberations that are indicated today and perhaps the policymaking which will come out of this committee's concern.

Dr. MOSHER. I think perhaps Lowell Hardin could answer this more directly about Latin America, but I might make two comments about agricultural development being a "systems" problem:

Today, in this meeting, the theme is the Green Revolution, because within the past 4 years it has been this biological breakthrough that has resulted in considerable production increases in particular parts of the world.

If this conference had been held 4 years ago, my guess is that we might have talked about transportation and agricultural development, because just before that the Friendship Highway in Thailand had resulted in an enormous increase in maize production in northeast Thailand.

At that time, as a matter of fact, there were many people who were saying, "See, look what happens if you really put in transportation."

If the conference had been held 30 years ago, my guess is that the theme of the conference might have been "irrigation" because just prior to that time there had been considerable parts of the world where there had been an enormous increase in agricultural production following the introduction of irrigation systems.

In a sense there is a tendency to give the credit for a breakthrough to *the last essential element to be added.* And if you look, for example, at the places in the world, where within the last 4 years the Green Revolution has made extensive and even extraordinary progress, they

are those parts of the world and those parts of individual countries where prior to that time the other essentials of agricultural development were already in place.

Now when we talk, as we do this morning, about some of the things that still have to be done, like getting irrigation where we don't now have it, or getting inputs where we don't have them, we are really asking ourselves: What in particular parts of the world are the missing elements at the present time?

### WHAT CAN BE DONE BY THE UNITED STATES

This leads to the second comment I would make on your question.

It does seem to me that with respect to what could be done through AID, in the U.S. bilateral program, we should take advantage of the fact that we are now pretty well aware of what the elements of this system are.

It would seem to me that AID should now have at least one knowledgeable adviser in each country who is well schooled in what the elements of creating a modern agriculture are and who can help individual governments analyze the problem in different parts of their own countries, to see just what elements of the system need to be added now.

### THE GREEN REVOLUTION AND POPULATION

Mr. TRAINOR. I am Mr. William J. Trainor of the State Department and I just wondered in some of the areas where the Green Revolution is taking place what is the prognosis of the group as to the effects of the revolution on population increases?

Dr. MOSHER. I think there is not much question but that the immediate impact of the Green Revolution, so far as population is concerned, is to decrease infant mortality and the mortality of mothers, thereby increasing the rate of population growth in the very shortest run.

But so far as I can see, the factors that really have to get to the forefront of people's attention before they begin to take the population problem seriously, is a different set of factors from those associated with the Green Revolution.

### REDUCING INFANT DEATH RATES

Mr. ZABLOCKI. Dr. Myers?

Mr. MYERS. May I add some comments to this?

I think what Dr. Mosher has said is absolutely right. As one improves food supplies and the quality of food, that is, improve nutrition, one reduces the infant death rate.

An interesting aspect of this from the population standpoint is that, in the opinion of many population specialists, this is the first step through which we have to go in order to generate interest in indigenous populations in birth control and population control. If they are assured that more children will live to maturity, people are willing to reduce the total number of children with which they start. The urge to have surviving children is strong and there is little incentive to

limit the number of births until the frequency of infant deaths can be reduced.

A second aspect of the Green Revolution that seems to me to be hopeful with respect to population control is that as the economical welfare of people improves, generally speaking, their concern about overpopulation increases. They become more concerned about providing economic opportunities to their children and, therefore, are more interested in limiting family size.

I would suggest, therefore, that the Green Revolution will, in the little bit beyond the near term, have a very beneficial effect on efforts to stabilize population numbers.

Mr. ZABLOCKI. It is my understanding one of the panelists of the third session has some views on this?

Mr. Paddock.

THE QUESTION OF POPULATION

Mr. PADDOCK. I believe this question of population is an extremely important one, and I am really surprised it has not come up before now. If it were not for the growth in the world's population, we would not be discussing the Green Revolution.

I think it is perfectly obvious that if you provide these countries with more food, there will be more people. There is no alternative since we are not able to limit births. I am concerned over the consequences of increasing the food supply when we have no way, really, to stop the population explosion. The dismal theory of Malthus, in a way, says that if there is not any limit to the population growth except starvation and pestilence, then no matter how favorable the environment or technology, the end result will be misery and starvation.

Kenneth Boulding has come along with a worse corollary, his utterly dismal theorem that says if the only check on population is starvation and misery and you introduce another improvement in technology which increases the food supply, then the ultimate effect is to increase the amount of misery because you increase the total number of people.

THE CASE OF IRELAND

A good example is Ireland. The Irish population in the 17th century had more or less come into balance with the land. There were 2 million Irishmen there, living in misery. Then along came a Green Revolution with the introduction of the Irish potato from this hemisphere. Because of the potato, output per acre grew spectacularly, as did the number of Irishmen in response.

The population grew to 8 million people by 1835. Then a new disease arrived in Ireland, the potato blight, which caused a series of crop losses.

Two million Irishmen died; 2 million Irishmen immigrated to the United States; leaving 4 million Irishmen living in Ireland in a degree of misery and poverty as severe as in the 17th century; that is, before the whole thing started.

The thought that by increasing incomes, you limit birth by increasing the desire of people to limit their population is an interesting theory. It may be true. There are no facts, however, to back it up.

I am personally concerned about undertaking programs which are virtually certain to result in an increase in population when mankind really has no way at the present time of limiting his population growth.

ALMOST SINFUL NOT TO USE KNOWLEDGE

Mr. ZABLOCKI. Dr. Hardin?

Mr. HARDIN. If I might comment on the question Mr. Tyler raised a moment ago with respect to Latin America and relate it to what Dr. Paddock has just said, I would argue that we should stress the quality of food, protein nutrition of people related to the quality of human beings.

In Latin America frequently the concern is that excess supplies will drive down prices at the farm level. This would create greater problems than now exist. Witness Brazil's experience with coffee. In this situation, might it be wise to push programs which improve the biological quality of foodstuffs? I'm thinking especially of the genetic manipulation of basic food crops. Mr. Freeman stressed the point this morning. But one has only to look at what happens when scientific knowledge is applied to improving the diets of preschool-age children and attendant influence on mental health and longevity.

If we sit here, if we do not help apply that science which is now available, we are knowingly contributing to poor mental and physical health of a generation. It s almost sinful, it seems to me, for society to permit widespread protein malnutrition in this the last quarter of the 20th century.

I do not know, Dr. Paddock, whether or not adequately nourished people who have better ability to think and act will then rationally limit family size, but I would like to see this theorem tested.

Mr. ZABLOCKI. The Chair will now entertain questions from the members of the committee.

Mr. FINDLEY. Not at this point, Mr. Chairman, thank you.

NEED REVISION IN AID PROGRAM

Mr. ZABLOCKI. Dr. Mosher, on page 19 of your statement, you suggest, "our AID policies need to be revised in the light of changed circumstances."

Could you be more specific what changes are needed and why?

Mr. MOSHER. In the first place, when the question was asked earlier whether AID should be conducting research of the type in which the Rockefeller and Ford Foundations have pioneered, I was reminded of my conviction that AID and its predecessor agencies should never have been criticized for what they did or did not do because they have never had a mandate that could allow them to do what they need to do.

I think the first requirement for a sound bilateral aid program is that technical assistance and some, but not all, related development assistance be sufficiently divorced from the political process that it can have its own personnel policy, its own program formation, so that over a period of years it can develop a program that is professionally determined on the basis of the requirements for agricultural development, and be allowed to pursue these activities year after year.

ECONOMIC VS. POLITICAL AID

The second indicated change, it seems to me, is that in some way there needs to be a dichotomy, organizationally, that distinguishes economic aid which is definitely aimed at economic development from that economic aid that is politically motivated for one reason or another. The second of those types of economic aid is one that is with us and will continue to be with us. As matters stand now, one of the difficulties in getting efficient programs consistently related to the problems of agricultural devolopment is that policies keep changing from year to year. The countries in which AID is authorized to operate keep changing, and the proportions in which funds can be allocated to different countries keep changing from year to year in response to shifting political considerations.

In the third place, it seems to me that, whereas, in the recent past, the effort has been to put the bilateral assistance where it could have the greatest short-term payoff, a change is needed so that some of the countries that are not yet at a point where that rapid payoff can occur, can reach that point. This goes back to the statement I made in my paper that where the Green Revolution has proceeded most rapidly has been in parts of the world where a lot of other things have been done previously.

As for our present problems, take, for example, the statement that was made earlier about dryland farming in India: that the Green Revolution does not touch it.

Well, we are never going to get a quick payoff in dryland farming in India until after 6, 8, 10, or 12 years of activities that are essential in order to get to the point where a substantial impact on aggregate production is possible.

CONTINUITY OF POLICY, PERSONNEL

In summary, it seems to me that if the AID agency were in a position to have continuity of policy and personnel and attract first-class people it could then take what we now know about the system of agriculture, and the various components of development that are essential, and tailer each country program to its specific needs.

Part of such a program would be the same procedure that has made the Green Revolution possible in biological research, proceeding with that on the present crops and to applying it to a lot of other crops.

But part of it, also, would be to work on those factors that are prerequiste to the readiness of individual countries and parts of countries to move ahead rapidly.

Mr. ZABLOCKI. Thank you, Dr. Mosher.

I realize that the time period has expired. However, building on what you have just stated, what we have heard from others, and with what we will hear later today in the third session, I am sure we can take off on another symposium, as to the future of our AID program.

At this time, I will call upon my colleague with the committee, the Honorable William S. Broomfield, to introduce the next speaker.

## SESSION III: PLANNING FOR THE FUTURE OF THE GREEN REVOLUTION

Mr. BROOMFIELD. Thank you very much, Mr. Chairman.

Now we have surveyed the past and present effects of the Green Revolution, the moment has come to look into the future.

To discuss planning for the future of this agricultural phenomenon we are pleased to have with us Dr. Lester Brown.

Dr. Brown is a senior fellow with the Overseas Development Council of Washington, D.C., and former Administrator of the International Agricultural Development Service, U.S. Department of Agriculture.

He holds degrees in agriculture, Rutgers University, 1955; economics, University of Maryland, 1959; and public administration, Harvard University, 1962.

Recognized as a leading authority on the world food problem while still in his late twenties he received the Arthur S. Flemming Award as one of the 10 outstanding young men in Federal service in 1965 and the Jaycee Award as one of the 10 outstanding young men of America in 1966.

The author of two books, "Man, Land and Food" and "Increasing World Food Output," Dr. Brown entered the Department of Agriculture in 1959 where he served as an international agricultural economist and Special Assistant to the Secretary of Agriculture on foreign agricultural policy before being named Administrator of IADS in November 1966.

It is a great pleasure for me, Dr. Brown, to introduce you at this time.

### STATEMENT OF LESTER R. BROWN, SENIOR FELLOW, OVERSEAS DEVELOPMENT COUNCIL

Mr. BROWN. A few years ago the threat of famine loomed large in the poor countries, particularly the densely populated ones in Asia. Today that threat is receding, thanks to the introduction of high-yielding wheats and rices. This paper is the story of the turnaround on the food front in the poor countries—the Green Revolution—and its meaning for man's efforts to eliminate hunger and poverty, to create jobs in the countryside, to slow the rush to the cities, and to improve the quality of life.

#### I. THE NATURE OF THE REVOLUTION [1]

For most reading this paper, the outstanding technological achievement of this generation was the recent landing on the moon by astronauts Armstrong and Aldrin. But for that majority of mankind suffering from chronic hunger and malnutrition, development of the

[1] The length of this paper results from a suggestion by the committee to summarize, for the record, the more pertinent findings of a book by the author on the Green Revolution. Entitled *Seeds of Change*, this book is to be published by Praeger Publishers in February 1970.

"miracle" wheats and rices is a far more meaningful achievement. For the 1 billion Asians whose staple food is rice, the "miracle rice" IR–8 is helping to fill literally hundreds of millions of rice bowls, once only half full. For those for whom hunger is a way of life, technology can offer no greater reward.

Advances in food production following introduction of the new seeds are without precedent in any country, rich or poor. In one of the most spectacular advances in cereal production ever recorded, Pakistan increased its wheat harvest nearly 60 percent between 1967 and 1969. This brought Pakistan, a nation of 130 million people and, as recently as 1967, the second largest recipient of U.S. food aid, to the brink of cereal self-sufficiency. Progress for Pakistan is not limited to wheat, for its record rice harvest in 1968 eliminated its deficit in rice, bringing it into the world market as a net exporter in 1969.

India's production of wheat, expanding much faster than the other cereals, climbed 50 percent between 1965 and 1969. Assuming political stability, present estimates indicate that India should be able to feed her vast and growing population from her own resources by 1972.

Ceylon's rice crop has increased 34 percent in the past 2 years. The Philippines, with four consecutive record rice harvests, has ended a half century of dependence on rice imports, becoming a rice exporter. Among the other Asian countries that are beginning to benefit from the new seeds are Turkey, Burma, Malaysia, Indonesia, and Vietnam. Even such remotely situated Asian countries as Afghanistan, Nepal, and Laos are using the new seeds.

The new wheats and rices are capable of doubling the yields of their predecessors, given sufficient water and fertilizer. Their principal distinguishing characteristic is their fertilizer responsiveness. Traditional varieties of wheat and rice were tall and thin-strawed. When fertilizer use exceeded 40 pounds per acre the tall, thin straw would not support the heavier yield of grain and the grain would fall down or "lodge," causing heavy losses of grain. The new cereals are short and stiff-strawed, making them capable of responding to nitrogen applications up to 120 pounds per acre. The new seeds are also earlier maturing, more adaptable, and more efficient. One pound of nitrogen applied to traditional cereals raised yields about 10 pounds; a pound applied to the new ones yields an additional 15 to 20 pounds of grain. The new seeds are also early maturing and more adaptable to variation in daylength. The dramatic superiority of the new seeds underlies their rapid spread. In Asia where they are being adopted most rapidly, the total acreage planted to the new seeds has grown as follows:

| | *Acres* |
|---|---|
| 1964–65 | 200 |
| 1965–66 | 37,000 |
| 1966–67 | 4,800,000 |
| 1967–68 | 20,000,000 |
| 1968–69 | 34,000,000 |

The agricultural breakthrough has not yet been achieved in all poor countries, and it is so far confined to cereals, principally wheat and rice. But it has already arrested the deteriorating food situation in some of the most populous countries of Asia—India, Pakistan, Indo-

nesia, Turkey, and the Philippines. The incidence of hunger is slowly beginning to decline as food consumption rises.

The new seeds, of course, do not provide an ultimate solution to the food-population problem. The collision between population growth and food production has been averted only temporarily. But the new seeds have bought time in which to seek a breakthrough in contraception comparable to that in plant breeding.

*Engines of progress*

The word "revolution" has been greatly abused, but no other term adequately describes the effects of the new seeds on the poor countries where they are being used. Rapid increases in cereal production are but one aspect of the agricultural breakthrough. The technological breakthrough achieved by agricultural scientists foreshadows widespread changes in the economic, social, and political orders of the poor countries. The new seeds are bringing far-reaching changes in every segment of society. They may be to the agricultural revolution in the poor countries what the steam engine was to the Industrial Revolution in Europe.

Most obviously, the new seeds demand an entirely different set of husbandry practices. If farmers are to realize the genetic potential of these seeds, they may need to increase the plant population or to change the time of planting or the depth of seeding; they must irrigate more frequently and with more precision; they must use fertilizer in large quantities and weed carefully lest the fertilizer be converted into weeds instead of grain.

As the mold of agricultural tradition is broken, farmers become more susceptible to change in other areas. They may become more interested in education and more receptive to family planning. The economic and political relationships between farmers and the rest of the economy begin to change fundamentally.

*Technology by the shipload*

The new seeds have been supplied to the poor countries on a virtually costless basis; millions of farmers who are planting them are reaping huge profits. Countries such as India, Pakistan, and Turkey imported samples of Mexican wheats for testing. Once the seeds' adaptability to local conditions was established, the countries imported them from Mexico by the shipload (see Table 1), and at prices only marginally higher than world market prices for wheat. The real additional cost was only the modest difference between the cost of the Mexican wheat seed and the world market price.

TABLE 1.—IMPORTS OF HIGH-YIELDING MEXICAN-WHEAT SEED INTO ASIA

| Country | Crop year | Tonnage imported | Country | Crop year | Tonnage imported |
|---|---|---|---|---|---|
| Afghanistan | 1967 | 170 | Pakistan | 1966 | 350 |
| India | 1966 | 250 | | 1967 | 50 |
| | 1967 | 18,000 | | 1968 | 42,000 |
| Nepal | 1966 | 38 | Turkey | 1967 | 60 |
| | 1967 | 450 | | 1968 | 22,000 |

Source: Dana Dalrymple, "Imports and Plantings of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations," Washington, D.C.: International Agricultural Development Service, U.S. Department of Agriculture, Washington, 1968, pp. 2–3

Not only was the new technology essentially free but, because the seeds could be imported in bulk, the time required for seed multiplication was greatly reduced. Normally the development of a new variety begins with a small handful of seed which is multiplied to a half bushel, then a quarter ton, ten tons, four hundred tons, eventually producing enough to release the seed commercially. Pakistan imported 42,000 tons of the new wheat seeds in 1967–68, enough to plant more than a million acres. When this crop was harvested, it provided enough seed to cover all of Pakistan's wheat land, thus telescoping into two years a process normally requiring several years.

TABLE 2.—AREA PLANTED TO HIGH-YIELDING MEXICAN WHEATS

| Country | Crop year | Planted area (acres) | Country | Crop year | Planted area (acres) |
|---|---|---|---|---|---|
| Afghanistan | 1967 | 4,500 | Nepal | 1966 | 3,500 |
| | 1968 | 65,000 | | 1967 | 16,200 |
| | 1969 | 300,000 | | 1968 | 61,300 |
| India | 1966 | 7,400 | Pakistan | 1966 | 12,000 |
| | 1967 | 1,278,000 | | 1967 | 255,000 |
| | 1968 | 6,681,000 | | 1968 | 1,800,000 |
| | 1969 | 10,000,000 | | 1969 | 6,000,000 |
| | | | Turkey | 1968 | 420,000 |
| | | | | 1969 | 1,780,000 |

Source. Dalrymple, op cit., p 2.

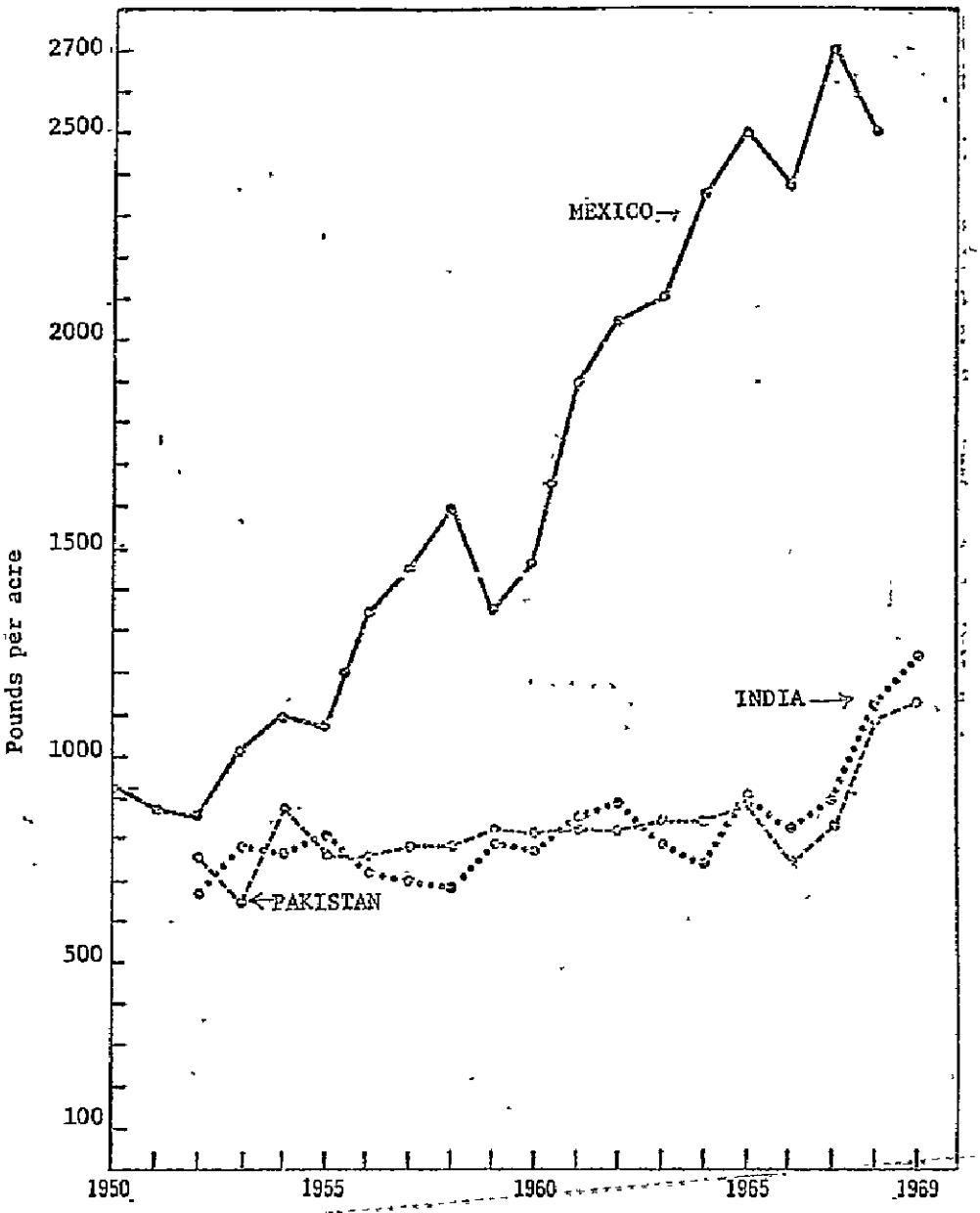
Imports of seed rice from the Philippines similarly accelerated the diffusion of the high-yielding dwarf rices, such as IR–8. Perhaps more important than the actual tonnage of the dwarf wheats and rices imported is the prototype they represent, which local plant breeders can refine and modify specifically for local growing conditions. The new seeds are thus raising the sights of agricultural scientists, ushering in a new era in agricultural research, Jaya and Padma, two promising rices released in Eastern India during 1969, are both local modifications of the dwarf prototype. Local improvements on the dwarf wheat prototypes are already in widespread use in India and Pakistan. As plantbreeding efforts continue, the first generation of high-yielding varieties is being replaced with a second generation.

Increasingly, farmers are viewing the future in terms of new seeds, new techniques, and a more productive life. Symbolizing this attitude is the response of the Filipino Farmer of the Year, 58-year-old Andres de la Cruz, when asked what variety of rice he was going to plant next season. "I don't know," he unhesitatingly answered. "I'm still waiting for a newer variety."

## II. TELESCOPIC PROGRESS

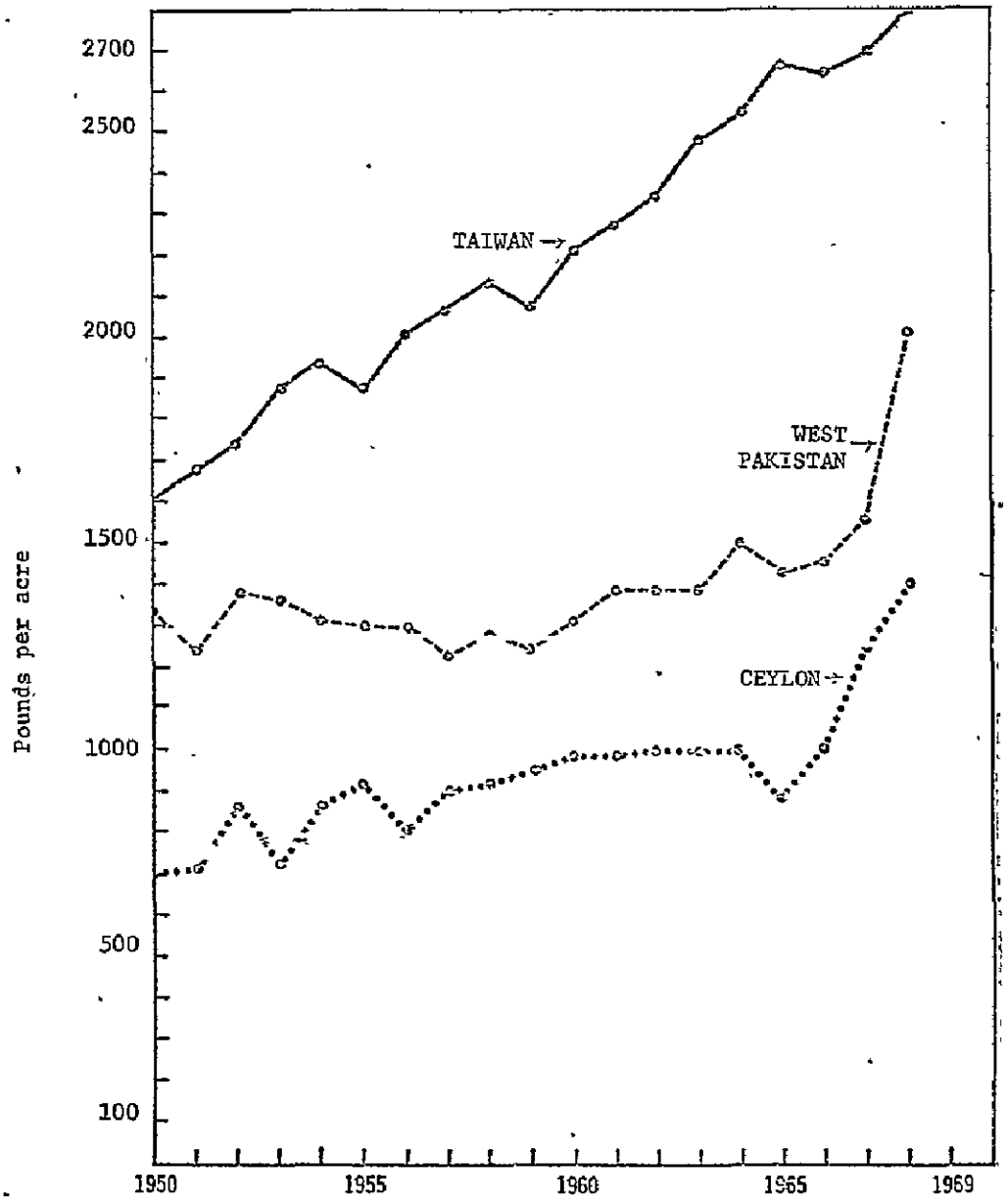
In some countries, the new seeds have already generated a "yield takeoff"—that is, an abrupt transition from a condition of near-static yields to one of rapid, continuing increases. Thus the new seeds have made possible a quantum jump in the production that farmers can get from an acre of land. The yield takeoff in wheat, shown for three countries in Figure 1, is easiest to illustrate. The line for Mexico is most dramatic, reflecting not only the adoption of the dwarf wheats

and the growing use of fertilizer by all wheat growers, but also the fact that a very large share of the wheat crop was brought under irrigation in Mexico between 1950 and 1960. The combination of these factors trebled wheat yields in 15 years.




WHEAT YIELDS IN MEXICO, PAKISTAN, AND INDIA

FIGURE 1.




RICE YIELDS IN WEST PAKISTAN, CEYLON AND TAIWAN

FIGURE 2

The recent annual percentage yield increases in wheat in India and Pakistan are more than double those following the introduction of hybrid corn in the United States. Several other poor countries—particularly Turkey, Afghanistan, Tunisia, Morocco, and Iran—appear to be on the verge of similar yields takeoffs in wheat.

The picture for rice is not yet so clear as for wheat (see Figure 2). The area planted to the new rices represents a smaller percentage of the total crop area than the area planted to the new wheats. Nevertheless, Ceylon and West Pakistan, where virtually all rice land is irrigated, have achieved a yield takeoff (see Table 3). Thailand, Indonesia, India, and East Pakistan are not far behind.

TABLE 3.—WHEAT AND RICE PRODUCTION TRENDS IN SELECTED COUNTRIES

[In thousands of metric tons]

| Year | Wheat | | Rice | | |
|---|---|---|---|---|---|
| | India | Pakistan | Ceylon | West Pakistan | Philippines |
| 1960 | 10,322 | 3,938 | 611 | 1,547 | 2,408 |
| 1961 | 10,977 | 3,847 | 613 | 1,692 | 2,542 |
| 1962 | 12,072 | 4,129 | 682 | 1,645 | 2,579 |
| 1963 | 10,829 | 4,215 | 698 | 1,790 | 2,498 |
| 1964 | 9,853 | 4,197 | 716 | 2,028 | 2,595 |
| 1965 | 12,290 | 4,626 | 515 | 1,977 | 2,647 |
| 1966 | 10,424 | 3,786 | 649 | 2,049 | 2,657 |
| 1967 | 11,393 | 4,394 | 780 | 2,288 | 2,832 |
| 1968 | 16,568 | 6,477 | 913 | 3,150 | 2,990 |
| 1969 | 18,000 | 7,000 | (1) | (1) | (1) |

[1] Not available

Source: U.S Department of Agriculture

These yield takeoffs are occurring in the poor countries today at a much earlier stage in their development than the comparable breakthroughs that took place in North America, Western Europe, and Japan. It does mean that there is a real possibility that the poor countries can telescope into a few years much of the progress that it has taken decades to achieve elsewhere. This promise, so familiar to readers of the literature of development, has often bred more disillusionment than hope among peoples beset with the problems of mere survival. But the agricultural revolution gives substance to the promise as nothing else has in the poor countries up to now.

*Higher incomes*

Increased production from the new seeds is abruptly raising incomes and living standards for literally millions of rural families in poor countries throughout the world. It is this incredible opportunity to raise incomes with the new seeds that underlies their rapid spread from country to country, village to village, and from farm to farm.

Table 4 compares typical returns realized from the new varieties with those from local varieties. In Turkey, the net profits of farmers growing the dwarf wheats are two and a half times those derived from local varieties; in Pakistan, somewhat more than four to one; in India, four and a half to one. In West Pakistan, with virtually all rice under irrigation, the margin in rice is just under two to one; in East Pakistan, where irrigation is limited and the high-yielding rices are grown mostly during the dry season, it is nearly four to one. In the Philippines the margin is much less; consumer resistance to the taste and texture of IR–8 reduced its price to 30 percent below that of traditional varieties, thus offsetting some of its enormous yield advantage. Even so, incomes of farmers growing IR–8 were nearly twice those of farmers growing local varieties.

TABLE 4—COMPARISON OF NET INCOME PER ACRE FOR LOCAL AND HIGH-YIELDING VARIETIES[1]

| | Local varieties | High-yielding varieties |
|---|---|---|
| Wheat | | |
| Turkey | $32 | $80 |
| Pakistan | 13 | 54 |
| India | 17 | 76 |
| Rice | | |
| West Pakistan | 25 | 45 |
| East Pakistan | 30 | 119 |
| Philippines | 81 | 140 |

[1] Data are drawn from a number of sources and represent either attempts to estimate national averages or the results of surveys. The data therefore should be taken as indicating the orders of magnitude of net income with the prices prevailing at the time of the estimate. Within any country there is a great variation, depending upon yields and costs of inputs. Most data are for the 1968 crop year.

*The thirst for water*

The new seeds are generating an enormous thirst for irrigation water among millions of farmers in the poor countries where they are being introduced. For many, water has suddenly become the key to a better life. With an adequate supply of water, farmers can use the new wheats or rices, raise their living standards, and enter the twentieth century; without it, they remain tied to traditional agriculture, merely eking out a subsistence living.

Already the new seeds, and exceptionally favorable farm prices, are having an effect on irrigation strategies. Tubewells (closed cylindrical shafts driven into the ground) and electric pumps have suddenly become popular with farmers. Accordingly, governments have put more emphasis on encouraging small-scale irrigation that farmers can install in a matter of days or weeks rather than on huge irrigation systems that take many years and hundreds of millions of dollars to construct.

In India and Pakistan, the greater demand for water has meant a dramatic increase in small-scale irrigation, particularly tubewells. Pakistan's "peasant farmers" installed 32,000 private tubewells, costing some $50 million over a 5-year span during the mid-sixties. Each 5,000 wells adds an estimated 1 million acre-feet to the yearly supply of irrigation water. Most important, this new source is under the farmer's personal management, enabling him to control very precisely the amount and timing of the water delivered to his crops.

During the 1968 crop year, Indian farmers installed 42,000 tubewells, which should provide an additional 8 million acre-feet of water. The Indian government installed another thousand to be operated by the state. Farmers purchased 200,000 pump sets, a large proportion of which replaced traditional bullock- or hand-powered water lifting devices.

Farmers in the delta areas of Thailand, South Vietnam, and East Pakistan are investing heavily in pumps to lift water from low-flowing streams and canals to field levels during the dry season. The combination of high-yielding rices and favorable prices makes such investment among the most profitable a farmer can undertake. It means that fields once idle during the dry season are now green with a second crop of rice.

*Farming around the calendar*

Wherever grain is grown, nature and tradition have usually combined to set a limit of one crop a year. In the higher latitudes, low temperatures during the winter preclude a second cereal crop. In the tropics, the lack of water during the dry season and the inability to maintain soil fertility have traditionally limited multiple cropping. Low temperatures remain an insurmountable obstacle in the temperate zones, but the constraints in the tropics are being removed by the new technologies.

The genetic characteristics of the new varieties—high yields, early maturity, and reduced sensitivity to daylength—open new vistas for multiple cropping. Farming around the calendar with two, three, and occasionally even four crops per year is becoming feasible in the tropical and subtropical regions, wherever water is available. Scientists at Los Banos regularly harvest three crops of rice per year. Each acre they plant yields six tons annually, roughly three times the average annual yield of corn, the highest yielding cereal in the United States. Farmers in the State of Mysore, India, are now producing three crops of hybrid corn every 14 months, using intensive applications of both fertilizer and irrigation water.

As multiple cropping spreads, it is profoundly altering the way of life in the countryside, divorcing it from the traditional seasonal crop cycle, which dictated not only planting and harvesting times but the timing of religious festivals, weddings, and a host of other social events as well. Land which traditionally lay idle during the dry season is being used more and more to produce food.

What had not been realized earlier was the great yield advantage of the dry season over the wet season, providing, of course, water is available. Data from both Indonesia and the Philippines show higher yields in the dry season than in the wet season for high-yielding rices grown at several different sites. Although environmental conditions varied widely among the sites, dry-season yields were consistently higher, averaging 52 per cent above those during the wet season.

Different cereals are often combined in the cropping sequence. In central and northern India, and in parts of Pakistan where rice is normally grown during the rainy season, it's now possible to harvest the early-maturing rice in time to plant a crop of high-yielding wheat in the dry season. Grain sorghum is a natural to combine with rice in the dry season. With water and fertilizer, certain varieties of sorghum tiller after harvest, i.e., generate new stems and leaves, to produce a second and third crop of grain from the original planting. Fields at Los Banos are producing eight tons of grain a year from a single acre planted successively with rice and sorghum. Heretofore, farmers in much of Asia have harvested scarcely half a ton per year.

The economic advantages of farming during the dry season are obvious. The increased utilization of farm labor, draft animals, and farm equipment which formerly lay idle in the dry season, combined with higher yields, makes dry season cropping exceedingly profitable. And the likelihood of substantially higher profits justifies investments in dry-season irrigation facilities, such as tubewells, or water-im-

pounding structures, which were not financially attractive with the older varieties.

Multiple cropping in the equatorial latitudes makes a virtue of the very solar energy that has such a debilitating effect on human beings in these regions. Fortunately, its potential is greatest where hunger and malnutrition are most acute—the tropical-subtropical regions, which are well endowed with solar energy and rainfall, and have temperatures favorable to year-round crop growth.

### III. TRANSFERRING TECHNOLOGY ACROSS BORDERS

*Global network of research institutes*

The transfer of the new seeds and associated technologies across national boundaries which has made the agricultural revolution possible is impressive in scale. But perhaps even more impressive is the fact that this transfer of technology is being institutionalized. This provides strong reason for believing that the momentum of the revolution will be sustained and will not dissipate after a few spectacular harvests, that it is not a one-shot affair but the beginning of a new era of continuous technological change and progress.

The institutions involved in this transfer include agricultural research centers (supported largely by private foundations), multinational corporations engaged in what has come to be called "agribusiness," universities and national and international assistance agencies. American experience has played a formative part in the role each of these institutions has played.

For example, the initial investment made by the Rockefeller Foundation in wheat research in Mexico in 1943 has already yielded returns of 700 percent *per year* for Mexico alone. The ultimate global return will not be known for many years, but it is apparent that it will be fantastically high. The acreage planted to Mexican wheats in Asia is now seven times that planted in Mexico.

Public and private investment in research on hybrid corn in the United States has also yielded a social return of $7 yearly for every dollar invested. And this does not, of course, include the benefits from the use of these hybrids outside the United States. Data on overall investments on publicly financed agricultural research in both the United States and Mexico indicate returns of 300 percent yearly. These estimates do not include most of the work undertaken by private agribusiness corporations, which today finance over half of all U.S. agricultural research.

Perhaps the single most profitable investment in agricultural research to date is that of the Ford and Rockefeller Foundations in the International Rice Research Institute at Los Banos. The total expenditure at IRRI, including the initial investment in 1962 and the year-to-year operating costs was $15 million as of 1968. Sterling Wortman of the Rockefeller Foundation estimates that the 1967–68 rice harvest was $300 million higher because of the new IRRI varieties. The figure for 1968–69 may approach a billion dollars. These figures cannot be regarded as returns on research investment alone, since the additional production costs associated with the new varieties have

not been deducted. Nevertheless, it is clear that the return to society on the original investment is exceedingly high, and the benefits derived from the rices and improved production practices developed by IRRI are only beginning to appear.

Several institutions, including international assistance agencies, foundations, multinational corporations, government agencies, and research centers, are becoming loosely linked in an informal international network which greatly facilitates the transfer of agricultural technology among countries. But it was the Rockefeller and Ford Foundations that carried the institutionalization of technological transfer a giant step forward in the development of the new seeds. The decision by the two foundations to pool their resources and establish a global agricultural research network was an international event of enormous significance.

Spectacular though the results in cereal breeding are, many further breakthroughs, some not yet envisaged, are certain to occur as more and more resources are mobilized. The concentrated effort to share breeding materials and research results in an interconnected, systematic fashion is certain to bring handsome rewards. A good beginning has been made, but most of the benefits of this recently organized effort are reserved for the future.

### TRANSFERRING TECHNOLOGY: THE MULTINATIONAL CORPORATION

During the early decades of this century, nearly all agricultural research in the United States was government-sponsored, conducted by the Department of Agriculture and the State Experiment Stations. The extension services, led by county agents, were the principal means through which the results of this research reached individual farmers.

Since World War II this picture has changed dramatically. Today most agricultural research in the United States is conducted in the laboratories and on the experimental farms of the corporations, which manufacture farm implements, produce fertilizer and other farm supplies. Most of the new technology reaching American farmers today comes by way of new products and the highly trained sales and service forces of these corporations. "Agribusiness" has found it very profitable to invest in research and agricultural extension. The large-scale entry of agribusiness corporations into these activities in turn has made possible the innovative, dynamic character of American agriculture during the past quarter century.

There is good reason to think that the same process will take place in the poor countries. As increases in farm production become more dependent upon purchased inputs, and as the proportion of farm production that is marketed rises, investment in agribusiness becomes more important. In fact, that investment must grow much faster than agricultural production itself. It is difficult to see how this needed new instrument in the poor countries will be found without engaging the capital and the technical resources of the multinational corporation on an ever increasing scale.

While plant breeders were developing new varieties of wheat and rice, chemical engineers were scoring a comparable technical break-

through in the production of fertilizer. The key advance was made in the early sixties, when engineers at the M. W. Kellogg Company of Buffalo, N.Y., developed a more efficient process for synthesizing ammonia from atmospheric nitrogen. The new process uses huge centrifugal compressors which reduce by a third both the initial capital cost and the operating costs of ammonia plants. Though developed within the United States, this beneficial new technology being used by multinational fertilizer-producing firms knows no national boundaries. It promises to lower the cost of food production throughout the world.

Right now, with cereal prices still attractive and fertilizer prices declining, fertilizer use is rising at 16 percent a year in the poor countries. This is far faster than in the rich countries, where fertilizer use is much closer to saturation. The use of fertilizer in Brazil, essentially unchanged from 1960 to 1966, more than doubled in the succeeding three years. Fertilizer use in India, which increased only slowly during the early sixties, more than tripled from 1966 to 1969. The story in Pakistan and Turkey is much the same.

As another example, Standard Oil of New Jersey (ESSO) has a highly successful program in the Philippines for delivering the needed inputs to farmers. ESSO has established some 400 agro-service centers to serve as marketing outlets, not only for the fertilizer produced at ESSO's plant in the Philippines, but also for other associated inputs, such as seed, pesticides, and farm implements. Manned by trained agriculturists who can provide farmers with technological advice and services, these have become one-stop shopping centers for Filipino farmers. Established just as the new varieties were catching on, they are making a strategic contribution to the gains in Philippine rice production.

In the 1970's, agribusiness investment by private multinational firms in some poor countries could far surpass that going into extractive industries and thus be much more welcome because it would more directly stimulate local industrial activity and create employment. There is a challenge here to both the multinational corporations and the poor countries. The former, in their pursuit of ever more efficient combinations of raw materials, labor, management, and markets, have to demonstrate an interest in the local economy. They have to be truly multinational investors, not just foreign investors. They have to be willing to invest for the long haul, not just for the quick result.

The poor countries, on the other hand, have to try to "denationalize" the subject of agribusiness investment and treat it for what it is: an amazingly efficient way of institutionalizing the transfer of technical knowledge in agriculture. The agricultural revolution provides the setting for a more pragmatic approach to this touchy issue.

## IV. SELECTED SECOND GENERATION PROBLEMS

### *Seeds of instability*

In December 1968, in Tanjore, one of India's model agricultural development districts, 42 persons were burned to death in a tragic clash between two groups of landless laborers. They were fighting over how best to get a share of the benefits from the new seeds being planted by

land-owners in the district. One group was willing to work at prevailing wage rates; the other wanted to enforce a boycott against the farms where the new seeds were being planted until landlords agreed to raise wages and share some of the handsome profits that were being realized with those who owned no land.[1]

Eugene Black has observed that economic development "is a fickle process; it destroys old habits and attitudes toward life and work even as it creates new opportunities: it often raises hopes much faster than the level of satisfactions." The introduction of the new seeds is bearing out this observation on a grand scale. They not only double the level of production over the levels of local varieties, but in doing so they often triple or quadruple profits. Millions of farmers have suddenly found themselves earning incomes that they had not dreamed were possible. The aspirations of millions of others, especially rural laborers without land, are being aroused in the process. As the new seeds and the associated new technologies spread, they introduce rapid and sweeping changes, creating a wave of expectations throughout society and placing great pressure on the existing social order and political system.

Conflicts are bound to arise between landowners and tenants, and between both of these groups and landless laborers. Conflicts will also arise between regions within a country where conditions in one prove more adaptable to the new technologies than do conditions in another. Most important, conflicts are bound to arise over the division of benefits between the countryside and the cities.

In Turkey, where wheat is the leading crop, the planting of high-yielding dwarf varieties is concentrated in the high-rainfall coastal lowlands. As farmers on the coast double their production using the new wheats, prices are likely to decline, leaving the dryland wheat farmer on the Anatolian Plateau in even worse circumstances than he is in now. The widening gap in rural prosperity between East and West Pakistan helped to undermine the authority of President Ayub Khan in 1968, leading to a period of considerable political turmoil in that country.

All technological innovation leads in some degree to these kinds of disruption. What is different about the introduction of the new seeds is the quantum jump in technology that they represent. In Western Europe, the United States, and Japan, agricultural modernization proceeded much more gradually, and it took place in societies that were accustomed to and expected continual technological change. The new seeds are being introduced abruptly on a massive scale in societies still practicing essentially Biblical agriculture. Centuries of technological progress are being compressed into decades and, in some extreme cases, into years. Herein lies the trauma of the agricultural revolution.

*The marketing crisis*

During April and May of 1968, scores of village schools closed in northern India. The reason was not student unrest or a teachers' strike.

[1] *New York Times*, December 28, 1968, p 3.

It was that schoolhouses were the only uninhabited buildings capable of storing a record crop of wheat that had already overwhelmed all other local storage facilities. The classrooms were filled to the ceiling with the new grain, and even that wasn't enough room. The overflow was finally stored in the open, unprotected from the weather. The bumper harvest was 35 percent greater than the previous record crop. A race began to get it to New Delhi and other cities where there were empty grain elevators before the monsoon rains came. Fortunately, the rains were late, and the exposed grain was safely loaded in boxcars.

With the new technologies, farmers' marketable surpluses of cereals have increased far faster, proportionately, than production. A farmer who is accustomed to marketing a fifth of his wheat harvest finds his marketable surplus tripled when his crop suddenly increases 40 percent. Even after retaining more for home consumption, as many are doing, farmers who have doubled their output with the new seeds are increasing their marketable surpluses several-fold.

When the wheat harvest is suddenly 35 percent greater than the previous record, as was the case in India in 1968, the marketable surpluses are bound to overwhelm all the components of the marketing system—storage, transport, and handling facilities. In West Pakistan, land planted to the new IR–8 rise rose from 10,000 acres to nearly a million in one year (1967–68); West Pakistan suddenly found itself with an exportable surplus of rice, but without the facilities needed to handle an export trade efficiently.

Four consecutive annual increases in the rice harvest in the Philippines are creating another kind of market crisis: a pressing need for more drying and warehousing facilities. In the Philippines, not only is the crop considerably larger, but the new, early-maturing rices must be harvested during the monsoon. Traditional methods of drying rice—in the sun along the roadside—are no longer feasible; farmers must use mechanical grain driers to dry the rice en route from the field to the storage bin.

The Green Revolution found some countries with marketing systems oriented to a considerable extent toward handling imported grain. Over the past 15 years, many large coastal cities in Asia, including Bombay, Karachi, Calcutta, and Djakarta, have been living literally from ship-to-mouth for extended periods off the wheat shipped each year under the United States food-aid program. In the mid-sixties these shipments averaged 450 million bushels yearly. Systems designed to move food surpluses from the countryside in the interior to the cities or to other food-deficit areas atrophied from disuse.

If one could add up the investment needed in marketing in countries using the new seeds, the total would be large indeed—in the billions of dollars. There is no more pressing need in agriculture in the poor countries today. Governments in the poor countries, AID, and the multilateral assistance agencies must address marketing with a sense of urgency matching that required to achieve the explosive gains in food production. Without such an effort, many of the potential production gains may evaporate.

*The disease threat*

One of the major risks of trying to establish a plant variety in an environment differing from that in which it was developed is that the new variety may fall prey to a disease to which it has no resistance. The classic example is the Irish potato famine of the late 1840's. Ireland had become dependent for its food on the lowly potato that had been introduced from the New World. The potato proved susceptible to blight; as the result of devastating crop losses, a million and a half Irishmen died of starvation, and even greater numbers of the survivors emigrated to the United States in ensuing decades. Famine and emigration; plus delayed marriages and low birth rates over the century and a quarter since the famine, have reduced Ireland's population to four million—just half of what it was when the potato blight hit.

The potato does not readily contract blight; the temperature and humidity, among other factors, have to be exactly right—or, rather, wrong. But when these very specific conditions occur, the crop failure can be total. The same is true of wheat rust and some other diseases attacking cereals. Since the 34 million acres of high-yielding cereals in Asia is planted largely to exogenous varieties, the disease threat is particularly acute. The new wheats, developed in Mexico, are rather resistant to the wheat rusts currently prevalent in Mexico, but not necessarily to those found on the opposite side of the globe.

While the threat of new diseases is real, there is much more preventive technology in the research bank today than when the potato blight struck in Ireland. As the exogenous varieties are crossed with local strains, the risk of a widespread outbreak of disease is reduced. At the same time, a greater number of new varieties is being used, and sources of germ plasma are becoming more diverse, diminishing the prospect of a total crop failure.

## CONSUMER RESISTANCE

Plant breeders also have to contend with consumer resistance. Newly introduced varieties are rarely as acceptable as those which they replace, and to which people are accustomed. The Mexican wheats, for example, are predominantly red wheats, but Indians and Pakistanis prefer amber wheats. The cooking qualities of IR–8 rice are invariably less popular than those of local varieties. The new rice is more chalky and is brittle, yielding more broken grains during milling.

Consumer resistance is reflected in the lower prices the new varieties command in the marketplace. Mexican wheats in Turkey sell for 10 percent less than local wheats; we saw earlier that the price for the new rice in the Philippines was 30 percent below that of traditional varieties. In Pakistan, wholesalers and millers have been reluctant to buy IR–8 because of its milling and cooking characteristics.

Again, however, time seems to be on the side of the new varieties. Crosses between them and the local strains often eliminate the less desirable characteristics, and consumer tastes adapt with time. Meanwhile, scores of local rice-research stations are kept informed about

these technical problems. New varieties that are more disease-resistant, that require less expensive protection in the form of chemical controls, and that have more desirable cooking and milling properties are being developed all the time.

*The need for U.S. coordination*

One of the great ironies of the Green Revolution is that the achievement of self-sufficiency in food may create a more serious foreign-exchange crisis than would continued dependence on food aid from abroad. Because food aid comes in kind and not in money, the savings in American food aid, for example, cannot be used to buy the increased amounts of fertilizer and other farm inputs needed to use the new seeds effectively.

There is no functioning mechanism within the United States government for transferring savings of food aid to increased aid in other forms so that at least a portion of the budget savings realized from reductions in the food-aid program could be shifted to finance the import of fertilizer and other items needed to sustain the agricultural revolution in aid-receiving countries. The two forms of aid are the responsibilities of separate Congressional committees: food aid is the agricultural committees; fertilizer and other forms of aid, of the foreign-affairs committees.

Some countries, such as oil-rich Iran, have the money with which to buy the inputs needed for self-sufficiency in food. But most do not. And for them, achievement of self-sufficiency will be costly in foreign exchange unless the United States devises a means of offsetting declines in food aid at least partially with other forms of aid.

## V. THE GREEN REVOLUTION AND THE POPULATION DILEMMA

*Redefining the population problem*

When Thomas Malthus published his gloomy treatise in 1798, he defined the population problem primarily in terms of food supplied and the threat of famine. Ever since, the threat of overpopulation has been perceived largely in his terms. In the 1960s, when national and international leaders were preoccupied with food scarities in the poor countries, the population problem was regarded as virually synonymous with the food-population problem. The two terms were often used interchangeably.

But as we enter the 1970s, we are faced with a need to redefine the population problem. After nearly two centuries, it is time to move beyond our legacy from Malthus.

Two independent factors, both bearing directly on the population issue, are forcing us to change our conception of it. The first is the agricultural breakthrough in the poor countries. Although this is by no means a solution to the population problem, it is diminishing the prospects of famine in the near future and buying time—perhaps an additional 15 years—in which to develop the contraceptive technologies, the will, and the strategies to stabilize global population growth.

While the threat of famine is diminishing, the number of young people entering labor markets is rising very rapidly. This is the second factor. The population explosion began in most poor countries 15 or 20 years ago and resulted in an almost immediate demand for additional food. But, since babies do not require employment, there is a grace period of 15 or 20 years on the job front that does not exist for food. As the seventies begin this grace period is ending. The food-population problem of the sixties is becoming the employment-population problem of the seventies. Feeding the increased numbers of people will not be easy, but is likely to be much more manageable than providing jobs.

With more and more young people entering the job market, the day of reckoning with the explosion in population growth has arrived. In some countries the number of young people coming of employment age will nearly double in a matter of years. If these millions of young people are not able to find jobs, the "labor force explosion" could pose an even greater threat to peace and stability than did the threat of famine in the sixties.

*The Green Revolution and family-planning*

Breakthroughs in food production and the prospects for effective family-planning efforts in poor countries are not unrelated. In addition to providing time in which to develop new contraceptive techniques, expanded food supplies can have a widespread effect on attitudes toward family planning. The lack of interest in family planning by most couples in these countries is largely due to their feeling that they must bear many children if a few are to survive to adulthood. With adequate food supplies, much larger numbers should survive. If assured food supplies are a precondition for the widespread adoption of family planning, as many sociologists believe, then this hurdle is not being crossed in some of the poor countries. Paradoxically, more food could eventually mean fewer people.

Reinforcing this contribution of the Green Revolution to family planning is the likelihood that those who adopt the new seeds will become much more susceptible to change in other areas, including the planning of their families. Once an individual breaks with tradition in agriculture, it becomes much easier for him to accept other kinds of change.

The most significant contribution of the Green Revolution to the population debate is likely to be the new context in which that debate will be carried on in the 1970's. The Green Revolution has, at least temporarily, laid the specter of famine to rest, permitting an employment crisis of vast proportions to surface in its place. Discussion of the urgency of limiting population growth must shift its focus from food to jobs.

## VI. SOLVING URBAN PROBLEMS IN THE COUNTRYSIDE

Since the Industrial Revolution, the most enduring social phenomenon everywhere has been the steady movement of population from the farm to the city. This historic trek has created the stark possibility that many great cities may become human trash heaps, the very opposite of the centers of civilization envisioned by the Greek philosophers.

Whether en route to Newark, New Jersey, or Calcutta, India, tens of millions have voted with their feet for almost any alternative to remaining in the countryside. In Newark they crowd the ghettos; in Calcutta a hundred thousand or so have become permanent inhabitants of the sidewalks. Now, the new seeds offer at least a possibility of slowing down the trek from countryside to city in the poor regions of the world, where the problems of "urbanization" are currently so pressing and potentially so explosive. But, ironically, if the new technologies are mismanaged, they can displace rural populations, driving them into the cities in great numbers.

Many current urban problems, whether in Newark or Calcutta, have their roots in the technological changes that have taken place in the countryside. The black migrant to Newark was driven out of the South by the mechanical cotton picker. After two centuries, one of the most important original reasons for bringing blacks to the United States from Africa—to pick cotton—suddenly disappeared. For many there was no alternative to migration to the urban areas of the North, if only to take advantage of better social services or bigger welfare checks.

A different kind of technological innovation drove millions from the rural areas of West Bengal into Calcutta. Two decades of exploding population growth, the result of successful malaria-eradication projects and other modern medical advances, increased the pressure of people on the land in Bengal to the point where literally millions of Bengalis had neither land nor the prospect of enough employment in the countryside to ward off starvation. Desperation led them to the city.

The plight of the cities is far worse in the poor countries than in the United States. Here, at least, there has been some reverse trek from the inner cities to the suburbs; the density of the ghettos in big cities like New York is not appreciably greater and may even be somewhat less than it was a generation ago. But there is no such hope of escape from Calcutta or Bombay or Recife.

Although rural-urban migration is as old as the first cities, the world's population remains predominantly rural; more than half of its people live in rural Asia, Africa, and Latin America. For years to come, this large and growing group must make its living in agriculture. The resources to create jobs in the cities can accommodate only a small fraction of the projected increase in rural population. This fact must dominate development planning in the seventies.

*Employment potential of the new seeds*

Properly managed, the new technologies can create farm employment and make rural life otherwise more attractive. Wherever data are available, they indicate that the new seeds require more labor than the traditional ones they replace. Farmers who wish to realize the genetic potential of the high-yielding seeds must prepare seedbeds more thoroughly, apply fertilizer more frequently, weed more carefully, and thresh and transport a large crop. All these operations require additional labor.

In northern India and West Pakistan, where the high-yielding wheats are catching on quickly, seasonal labor shortages have been

aggravated, forcing rural wages during harvest above the wages prevailing in the larger cities. A survey cited in an AID report from New Delhi in 1969 showed that the cash outlays for hired labor needed to produce the new rices are roughly double the outlays required for local rices. A scattering of data from several countries indicate that total labor used, both family and hired labor, is from 10 percent to as much as 60 percent greater with the new seeds, depending on local growing conditions and labor costs.

A report from the AID mission in New Delhi, addressed to the effect of the new wheats on employment, concludes:

> The Green Revolution has definitely been employment-creating. In the Punjab (state in northern India) there have been serious labor shortages during the April–June period when wheat is harvested, threshed, marketed, and the summer crop is sown. Wage rates (nonagricultural) have risen as high as $2.00–$3.25 per day. Agricultural labor rates have also risen. Mechanization is increasing rapidly, largely because of the labor shortages.

This conclusion is borne out by experience in such countries as Taiwan and Japan, where, as agriculture modernized, labor requirements increased. Japanese and Taiwanese farmers now invest about 170 man-days in the production and harvesting of an acre of rice, as compared with 125 man-days in India and 100 in the Philippines. But while more labor is required per acre in Japan and Taiwan, less labor is required per ton of grain. Available data suggest that a similar situation obtains in Turkey, India, and Pakistan, where labor used per ton of the new cereals averages perhaps 20 percent less than with traditional varieties.

### SELECTIVE MECHANIZATION

As wages rise, and as the new seeds make agriculture more profitable, mechanization becomes increasingly attractive. Perhaps the most immediate issue of the agricultural revolution is whether mechanization will come in such a way as to displace large numbers of farm laborers and thereby measurably worsen an already serious social problem.

As we saw earlier, there are bound to be serious conflicts over the division of benefits created by the new seeds between landowners and tenants, and between the countryside and the cities. If mechanization proceeds so rapidly that more millions are added to the army of unemployed in the rural areas and in the cities, the agricultural revolution could become a curse rather than a blessing.

But with the new seeds, selective mechanization can create jobs. Irrigation is a case in point. Traditional methods of irrigation, using human or animal power, often do not supply enough water to meet minimum needs. More important, phenomenal savings occur when mechanized water pumping is introduced. One study of pumping costs in India found that it costs 495 rupees to pump 10 acre-inches of water by hand, assuming a 40-foot lift. With draft animals powering a Persian wheel, the cost drops to 345 rupees, but the really startling gain comes with the use of a diesel engine; the cost then drops to 60 rupees.

As more water becomes available and production is boosted, more labor is required for land preparation, planting, fertilizing, weeding, harvesting, and threshing. When multiple cropping becomes possible, labor requirements may double or even treble, with the number of crops.

*Rising pressures for agricultural reform*

One of the puzzling dimensions of the agricultural revolution is why it is progressing so spectacularly in some poor countries but not catching on at all in others. It is true that new wheats and rices are better adapted to some countries than others, but this variability does not begin to explain the glaring contrasts. The Mexican dwarf wheats, for example, are spreading through much of Asia and parts of North Africa but are having little impact in Latin America outside of Mexico. Nor are the dwarf rices developed in the Philippines catching on rapidly in Latin America.

In general, the disparities are due to the inabilty of some governments to create the economic climate required to accommodate a breakthrough in agriculture—more specifically, to their inability to bring about land reform. Even if price incentives are provided, land ownership in many countries is too concentrated within a small segment of the population to permit an effective link between effort and reward for those who work the land. In other cases, the small size of land holdings or the fact that land tenure is determined by archaic customs effectively prevents the introduction of modern technologies.

As agriculture emerges from its traditional subsistence state to modern commercial farming, with the need to purchase inputs and market production surpluses, it becomes progressively more important to ensure that adequate rewards accrue directly to the man who tills the soil. Indeed, it is hard to see how there can be any meaningful modernization of food production in Latin America and Africa south of the Sahara unless land is registered, deeded, and distributed more equitably among those who till it. If land titles in Africa continue to be determined arbitrarily by a chief or headman, there simply will be no basis for investment in the land. If the link between effort and reward in Latin America is weakened because huge tracts of land are owned by absentee landlords or country gentlemen with little interest in commercial farming, millions will continue to abandon the countryside for the impoverished city barrios.

*Trade policy and urban problems*

Agricultural trade policy in the rich countries and urban problems in the poor countries are closely related. The easiest way to handle urban problems in the poor countries is to provide incentives to keep people in the countryside. This in turn requires expending external markets for the additional production the new seeds make possible.

As long as there is an internal food deficit to produce against, production can expand rather rapidly. But once this is filled, demand will increase rapidly only if export markets are developed. A rise in domestic demand depends upon a rapid and continuing indigenous growth in incomes; a rise in the demand for export depends upon gaining access to the highly protected grain markets of the rich coun-

tries, particularly Japan and Western Europe. This increasingly recognizable relationship between trade policy and urban problems is certain to make trade relationships between the rich and poor countries a major issue in the seventies.

## VII. THE NEW SEEDS AND THE AMERICAN FARMER

The new seeds are having an impact that extends far beyond the borders of the countries where they are being planted. Designed specifically to capitalize on the greater supply of solar energy and the year-round growing temperatures of the tropics, they are strengthening the comparative advantage of the tropical-subtropical countries in cereal production. Poor countries, until recently grain importers, are appearing with increasing frequency on the export side of the ledger.

Even without knowing exactly how the new technologies will reorder world agricultural trade, we can already see the beginnings of significant change: The recent production gains in the poor countries challenge all the rich countries, particularly the more protectionist ones in Europe, and Japan. These countries will be pressed to open their markets to competitively produced farm exports from the poor countries. They challenge the American farmer in a very different way. He must adjust to declining levels of food-aid exports, principally wheat, while simultaneously adjusting to expanding opportunities for commercial exports of the wide range of commodities he produces so efficiently.

During the mid-sixties, two-fifths of the entire United States wheat crop was shipped abroad as food aid, one-fifth to India alone. Shipments in 1964 exceeded 500 million bushels, but by 1968 they had declined 45 percent, to 283 million bushels (Table 5).

TABLE 5—WHEAT EXPORTS UNDER THE U S FOOD AID PROGRAM

| Year | Bushels[1] | Year | Bushels[1] |
|---|---|---|---|
| 1954 | 15 | 1962 | 370 |
| 1955 | 132 | 1963 | 462 |
| 1956 | 253 | 1964 | 509 |
| 1957 | 243 | 1965 | 449 |
| 1958 | 219 | 1966 | 461 |
| 1959 | 254 | 1967 | 342 |
| 1960 | 381 | 1968 | 283 |
| 1961 | 384 | | |

[1] In millions.

Source: U.S. Department of Agriculture

If Pakistan should become self-sufficient in cereal production in 1970, as scheduled, and if India should follow within a year or two, then food aid could drop much lower, requiring continuing structural adjustments in U.S. agriculture.

Declines in food aid, coming at the same time that the trend of rising farm exports to Europe has been arrested by protectionism, are resulting in reduced acreages of food grains in the United States. Wheat-acreage allotments, expanded to cope with scarcity in 1967, were reduced 13 percent in 1968, 13 percent in 1969, and a planned 12

percent in 1970. Rice acreage was reduced 10 percent in 1969 and will probably be reduced further in 1970. Since it costs less to idle land than to produce grains on the same land and ship it abroad as food aid, these reductions save the U.S. Treasury dollars without any necessary loss in farm income.

What is lost is a great deal of farm-related business, especially in the Northern Great Plains, where much of the wheat is grown and where local economies depend on business generated by the production, marketing, and storage of wheat. Farm-supply and service industries in rural communities suffer when wheat acreage is reduced. The rural communities derive some benefit from payments made to farmers to take acreage out of production. They may not suffer any loss if farmers shift from wheat to feed grains or beef cattle, for which there has been a buoyant demand for many years. Nonetheless, when the government shifts gears in agricultural policy, especially when it shifts to a lower gear, the effect in the rural areas is inevitably unsettling.

At the first glance, it might appear that the trend toward self-sufficiency in wheat or rice in the poor countries would throttle growth in the world trade in farm products and damage U.S. export prospects in particular. But this is not likely to be, since the associated rise in incomes creates new markets for U.S. farm products. In many temperate-zone farm products, the American producer is the most efficient in the world. As incomes rise, consumers everywhere demand a much greater variety of food. During the sixties, while the Japanese economy was expanding at more than 10 percent yearly and while it was achieving self-sufficiency in rice, its imports of U.S. farm products nearly tripled, approaching a billion dollars.

The increasing diversity of diets is reflected even in such basics as cereal consumption. Although the Philippines has achieved self-sufficiency in rice, for example, it is importing steadily growing tonnages of wheat. Indonesia may achieve self-sufficiency in rice and become an exporter of feed grains, but, like the Philippines, it must import more and more wheat to satisfy consumer demand as incomes resume their rise. Densely populated Taiwan, long an exporter of rice, imports growing quantities of wheat and even more rapidly growing quantities of feed grains, the latter to meet the soaring demand for the poultry and pork that higher incomes demand.

Studies show a close relationship between income levels abroad and imports of farm products from the United States. Countries with per capita incomes of more than $600 a year bought $7.80 worth of farm products per person in 1964. Where average incomes were between $200 and $600, sales averaged $4.18 per person; where incomes were under $200, sales were a mere 30 cents per person.

From the point of view of the American farmer, furthering the Green Revolution is a matter of simple self-interest. The American farmer should welcome the Green Revolution. Adjusting to the impact of the new seeds and associated technologies will require forward planning. But strengthening the economic position of the poor countries means, in effect, substituting commercial for concessional exports, putting exports on a much firmer basis, more dependent on the Amer-

ican farmer's ability to compete and less dependent on the political vagaries of government. In 1968, Asia, for the first time in history, replaced Europe as the leading outlet for U.S. farm exports. This is but one indication of the growing importance of the less-developed world for the American farmer. Significantly, Asia's displacement of Europe occurred despite the Green Revolution and the sharp decline in food-aid shipments to the region!

## VIII. TOWARD THE ERADICATION OF HUNGER

The new seeds, as we have seen, are seeds of change, promising to transform the economies of the poor countries, politicize the countryside, and alter the social order. But the new seeds imply something else for humanity, something of paramount importance: they invite mankind to set the goal of eliminating hunger from this planet.

We know now that hunger is inextricably linked with abject poverty. Its eradication depends less on encouraging new production than on expanding employment opportunities and raising incomes among the impoverished. The new seeds, because they promise both lower food costs and higher incomes, are making this relationship more obvious and thereby are making it more and more difficult not to accept the eradication of hunger for most of mankind as a practical achievable goal during the decade of the seventies.

Where death certificates are issued for preschool infants in the poor countries, death is generally attributed to measles, pneumonia, dysentery, or some other disease. In fact, these children are more likely to be the victims of malnutrition. A severely malnourished infant or child with low resistance can die of the most minor ailments. If all deaths that would not have occurred, given adequate nutrition, could be identified with reasonable accuracy and attributed to malnutrition, it would bring the suffering and social cost of malnutrition into much sharper focus.

### *What hunger is*

Hunger and malnutrition can be described statistically, but statistics alone have little meaning for most of us. The fact that half or two-thirds of the world's people are hungry or malnourished is difficult to comprehend. It does not move us to action. But hunger is meaningful when it is personalized, as the following account of hunger in Colombia by Frank Byrnes:

> Nine-year-old Ana Ruth did not know why her aunt had left her in the hospital. Her younger brother had died at home just two weeks before, and now, when the doctors and nurses came to talk to her, she asked what was going to happen to her. Too young to understand fully the prospect of dying, Ana Ruth was afraid that in some way she would have to part with the new sneakers, dark blue canvas with white rubber soles, that a doctor had given her. So she wore them day and night, lying in her hospital bed, and a sympathetic staff let her, for there is no getting used to watching children die.
>
> Most children in the developing world suffer at one time or another from malnutrition, particularly from protein deficiencies in their early years. The advanced symptoms are easily recognizable: bellies become bloated, legs swell up like balloons and hair turns reddish-blond and becomes brittle.
>
> Ana Ruth did not die. When her aunt, already overburdened with caring for

her own five children, decided to let the University of Valle's hospital worry about the little orphan girl's final care and burial, attendants rushed her to the Metabolic Unit, where Dr. Alberto G. Pradilla and his staff took over. Her condition was critical. She was suffering not only from serious protein deficiency, the disease called "kwashiokor", but also from pneumonia, which frequently occurs in victims of malnutrition. As they treated Ana Ruth for pneumonia, doctors also placed her on a minimum-level protein diet, watching carefully the sodium-potassium balance in her system so as to avoid the risk of sudden death from additional strain on the heart.

Ana Ruth responded rapidly. She lost over two pounds of water a day for three consecutive days, and the bloating and swelling abated. Once she was on a recovery diet, her abnormal hair fell out, and her head began to sprout a fuzz promising a luxuriant growth of silky black hair.[1]

Caloric intake, though a good quantitative indicator of food intake, is not a good indicator of diet quality. For this purpose, protein intake is much more satisfactory. Mose of the 1.9 billion who don't get enough calories also suffer from protein deficiencies. Such was the case with Ana Ruth and, very probably, her younger brother, who died two weeks prior to her admission to the hospital. The problem is not just a lack of protein per se but a lack of protein of high quality such as is available in animal products or légumes (peas, beans, soybeans, etc.).

*The cost of malnutrition*

Many of those who live in perpetual hunger do not die at Ana Ruth's age. Examples of the suffering they endure, however, are legion. It is estimated that four million people in India are totally blind and possibly three times as many are partially blind, largely owing to Vitamin A deficiencies. Perhaps one-third of the Indian mothers who die in childbirth die because of iron-deficiency anemia.

The effect of low levels of food-energy intake on the productivity of labor is easy to see. American construction firms, operating in developing countries and employing local labor, often find that they get high returns in worker output by investing in a good company cafeteria that serves employees three meals a day. But the scope of this problem is perhaps better illustrated by events during the summer of 1968, when India held its Olympic trials in New Delhi to select a track and field team to go to Mexico City in the fall. Although it had a population of 535 million to draw from, India failed to qualify a single athlete in any of the 32 track and field events. Not one of the contestants could meet the minimum Olympic qualifying standards to go to Mexico City. Outdated training techniques and a lack of public support were partly responsible, but the undernourishment of most of the population certainly contributed to this poor showing.

Although the relationship between diet and physical performance is well known, the parallel relationship between nutrition and mental performance has only recently been demonstrated. Protein shortages in the early years of life, impair development of the brain and central nervous system, permanently reducing learning capacity. Furthermore, this damage is irreversible. Protein shortages, today are depreciating the stock of human resources for at least a generation

[1] Frances C. Byrnes, "A Matter of Life and Death," Rockefeller Quarterly, p. 4.

to come. And no amount of investment in education can correct this damage.

Eliminating hunger and malnutrition requires a larger supply of food and the means to buy it. The agricultural revolution contributes to both. As the income of farmers is raised, they retain more of the food they produce for home consumption and also buy more goods and services, thus providing more employment and higher incomes for the non-farm population. This is turn expands demand for the increased food production. The effect of the agricultural revolution on cereal production per person is shown in Table 6. In Mexico, eight consecutive record harvests add up to some impressive gains, raising per capita cereal output far above that required for direct consumption, providing large quantities for conversion into animal protein. Mexico now has a solid resource base from which to develop a modern poultry and livestock industry.

This process is just beginning in Asia, but we can anticipate advances in at least some countries to match the Mexican performance. The breakthrough in cereal production in Asia is occurring first in wheat, as illustrated by the striking gains in both Pakistan and India. In these two countries, it is only beginning in rice, the leading staple, and other cereals. The countries achieving the greatest advances in rice produced per person thus far are Ceylon, Malaysia, and the Philippines.

TABLE 6.—PRODUCTION OF SELECTED CEREALS IN SELECTED COUNTRIES (POUNDS PER PERSON OF TOTAL POPULATION)

| | India—Wheat | Pakistan—Wheat | Ceylon—Rice | Mexico—All cereals |
|---|---|---|---|---|
| 1960 | 53 | 87 | 201 | 495 |
| 1961 | 55 | 83 | 196 | 496 |
| 1962 | 59 | 87 | 213 | 525 |
| 1963 | 51 | 86 | 218 | 546 |
| 1964 | 46 | 83 | 213 | 611 |
| 1965 | 56 | 90 | 150 | 639 |
| 1966 | 46 | 71 | 188 | 649 |
| 1967 | 49 | 80 | 216 | 655 |
| 1968 | 76 | 116 | 247 | 680 |
| 1969 | 80 | 121 | (1) | (1) |

[1] Not available.

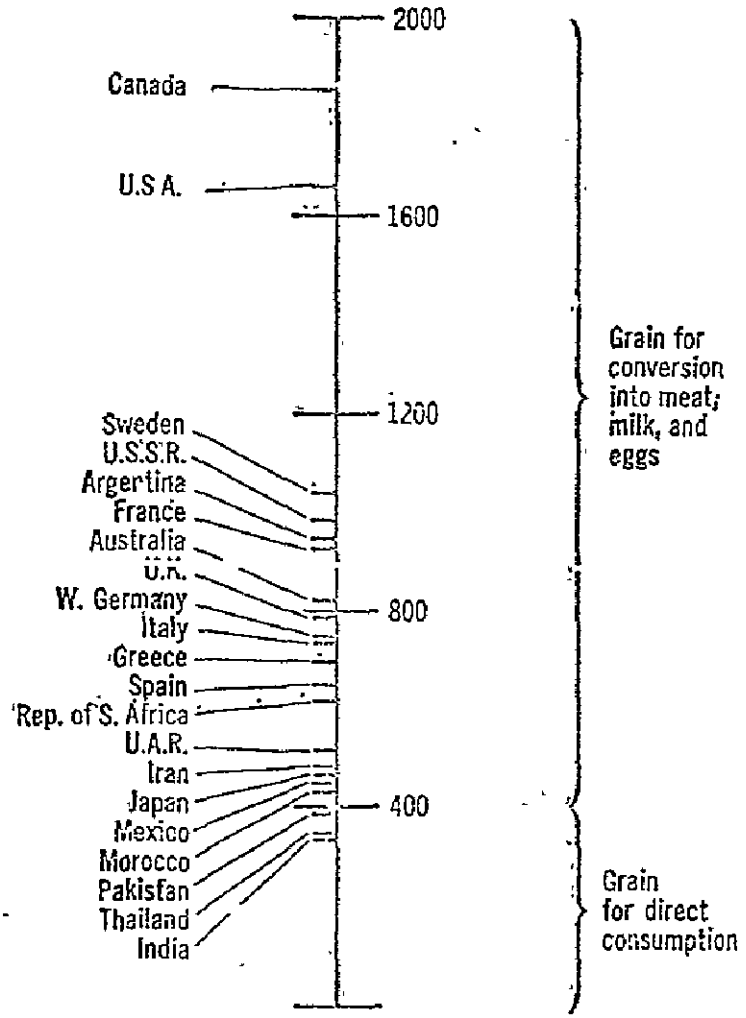
Source: U.S. Department of Agriculture.

But rising incomes, while essential to the elimination of hunger and malnutrition in the poor countries in the long run, are not adequate to the immediate task. Protein hunger is much more costly to eliminate than caloric hunger. The average North American uses some 1700 pounds of grain yearly, less than 10 per cent of which is consumed directly as bread, pastry and in other forms. The remainder is consumed indirectly in the form of meat, milk, and eggs. This contrasts sharply with the average person in the poor countries, who has only 400 pounds of grain, nearly all of which must be consumed directly to keep body and soul together.

In the past, diets improved significantly only when grain supplies began to exceed direct consumption needs, leaving large quantities to be converted into high-protein livestock products. But this is a costly way of achieving high-quality diets (see Figure 3). If cereals could be reengineered or fortified so that their protein quality approached that of livestock protein, the cost of achieving high-quality diets could be greatly reduced. There are many ways of doing this, including the development of high-protein cereals, fortifying with synthetic amino acids and many others.

FIGURE 3

GRAIN USE LADDER
(Pounds of Grain Used Per Person Per Year)*




*Includes grain used for food, feed, seed, and industrial purposes.

Source: U.S. Department of Agriculture, Data For 1959-61.

Plant breeders, biochemists, food technologists, and microbiologists are responding to this challenge. With the new seeds and other materials to work with, they can hope to achieve an adequate diet with the resources available in the poor countries. New technologies just coming off the drawing boards will have a major impact on nutrition during the 1970's.

*Assuming leadership*

For the first time in history, it is realistic to consider the eradication of hunger for the overwhelming majority of mankind. Breakthroughs in cereal production and the new food technologies make that a realistic, attainable objective, particularly if the United States were to take the lead in a new worldwide effort. Such an objective would remove the pall of indifference and disillusionment that recently has come to characterize American attitudes toward the world, and to restore the will and the generosity that made our great contribution to the agricultural revolution possible. It would show the world that we had not lost confidence in ourselves or in those abroad who so desperately need help.

At present, the average diets in the poor countries, which contain more than half of the world's people, are deficient in calories and protein. But enlightened agricultural policies, new food and agricultural technologies, and intelligent employment-creating programs should make it possible to bring the average diet for virtually every country above the nutritional minimum by the end of the seventies. This would eliminate most hunger and malnutrition, leaving only fringe groups to be reached by special efforts.

A decision by the United States to provide leadership in a global effort to eradicate hunger is not so ambitious or so inconsistent with previous efforts as it might seem at first. Shortly after World War II, the United States decided that it would use its food resources to avert famine wherever it threatened. As a result, the world has not experienced a massive famine since the one in Bengal in 1943. Even when this policy meant that more of the American wheat crop would be consumed by aid recipients abroad than by the American people at home, as was the case in 1966 and 1967, it was nonetheless rigidly adhered to.

It was not beyond the resources of the American economy to assume the responsibility for avoiding famine. Nor, in the light of today's much greater knowledge and resources, is the goal of eradicating hunger on a global scale impossible to attain.

Turning these objectives into an operational plan requires that each country with a nutritional deficit develop a national strategy embodying the entire range of new agricultural and food technologies, including the use of high-yielding, high-protein seeds; more extensive use of fertilizer; the expansion of poultry and livestock industries; the manufacture of high-protein foods from vegetable sources; and fortification of food with vitamins, minerals, and essential amino acids.

The poor countries will need help in fashioning such plans, and the United States is uniquely qualified to provide it. The global research network in agriculture is financed and directed in large part by American foundations, and the largest and best-equipped multinational agribusiness corporations are based in the United States. Furthermore, the United States Government employs a greater pool of professional com-

petence than exists in any other country or international organization.

There is no worthier goal for America's international-assistance effort in the seventies than the conquest of hunger, and none more urgent—not because hunger is more widespread today than in the past, but because it has become so unnecessary. If we were not able to save Ana Ruth's brother in the situation described earlier, Ana Ruth herself was saved, and millions more like her can be saved. The eradication of global hunger is an exciting objective, one that the American people can identify with and support with enthusiasm.

*Employment and hunger*

Eradicating hunger means increasing the over-all supply of food, and we know how to do that. But, as we have seen, it also means expanding employment and raising purchasing power so that food is distributed evenly enough among the population to eradicate hunger.

Employment is the key here. The population explosion makes it certain that the number of young people entering the labor market will rise sharply in the seventies. If these entrants have no way of earning an income, they will serve to perpetuate the legacy of hunger and malnutrition.

Finding productive employment for these millions will tax the resources and ingenuity of the poor countries. It is dangerous arrogance to claim that Western experience offers much guidance in this situation. But the rich countries and the poor countries can work together to learn how to create more room in modern society for those who are clamoring for a place. After all, this is a problem common to both rich and poor nations.

We in the United States are not experts on the economics of labor-intensive activities, but this does not mean that we cannot help. In our assistance programs, for example, we can encourage selective farm mechanization and intensive cropping, because both are job-creating phenomena. At the same time, we can try to discourage the wholesale mechanization that displaces labor on a vast scale. We can provide the financing necessary to maintain adequate supplies of fertilizer, and we can help to establish the marketing, credit, and extension services needed to make modern labor-intensive agricultures possible.

Most important, we can adjust our trade policies so that they encourage the momentum of the Green Revolution rather than, as is often the case now, threaten to bring it to a halt. Trade policy should perhaps have pride of place on our agenda for the seventies, since trade provides 80 percent of the foreign exchange available to poor countries. It is also preferable to even the most sensitive assistance program, because it lacks the unpleasant psychological overtones of the aid-donor relationship. It has still another attraction in that export earnings from trade do not have to be repaid as does foreign aid, most of which consists of loans. For these and other reasons, trade is likely to be the basis of a confrontation between the rich and poor nations in the seventies.

## IX. THE RICH-POOR CONFRONTATION

The confrontation between poor and rich countries on the question of trade must be put on the agenda simply because it is the inevitable result of historical forces already in motion, the culmination of centuries of evolution in human rights. In addition, as surpluses of cereals

accumulate in poor countries, there will be increasingly strong political pressures on rich countries to open up their markets to fair competition. Jobs will be at stake, jobs that the poor countries simply cannot afford not to have. Equally important, national pride will be at stake, because if the poor countries are not allowed to earn their way in the markets of the rich when they develop exportable surpluses, they will conclude that the rich countries are attempting to perpetuate the dependent relationship.

The trade confrontation in the seventies promises to be much more serious than in the sixties. The Kennedy round of tariff negotiations in the sixties was very much of, by, and for the rich countries, paying only lip-service to the needs of the poor countries. In the seventies, thanks in large part to the Green Revolution, the bargaining position of the poor countries will be much stronger and their arguments more persuasive. They will also be more militant because so much more will be at stake.

This trend is already becoming apparent. The gathering of Representatives of the 21 Latin American republics assembled at Vina del Mar in June 1969, produced a unanimous list of demands for American action to correct existing inequities in our economic relationships with our sister republics. This list, presented to President Nixon by the Chilean Ambassador in Washington, was but the first salvo of a battle that promises to dominate international relations in the seventies.

A recent remark by President Suharto of Indonesia further indicates the growing tendency of poor countries to challenge the discrepancy between America's rhetoric and its actions in setting national priorities. As President Nixon and his entourage, basking in the light of the Apollo 11 moon landing, were leaving Indonesia, President Suharto, paraphrasing astronaut Neil Armstrong, commented: "A great leap for whom?" He was clearly implying that conditions in Indonesia had not been improved by the accomplishments of the American space program. The human condition in Indonesia had not been bettered in the least.

The poor countries will probably find many more allies among the rich in the seventies than they had in the sixties. Corporate leaders, bankers, and consumers in the United States and elsewhere are increasingly calling for liberalized trade policies in the national self-interest. As the full cost of trade barriers in agriculture and of discrimination against the poor countries becomes clear to more consumers in the rich countries, and as these barriers add to the inflationary spiral, the possibility emerges of re-enacting debates like that over England's Corn Laws a century and a quarter ago, this time in Europe and Japan. In the United States, sugar could be the focal issue. As the number of farmers and related special interests declines in the industrial countries, politicians there will be less willing to ask the consumer to pay high prices to protect uneconomic farm interests; there will be more and more pressure to adopt policies to provide food at the lowest possible cost.

One can imagine, for example, vociferous objection to the policy of setting sugar prices so as to support the beet sugar industry in the rich countries. Sugar can be produced at such advantage (less than half the cost) in tropical and subtropical climates that it is difficult to

justify protecting the beet-sugar producer from international competition. Yet virtually all the rich countries do so. Our own methods of protection are especially capricious. By establishing quotas for several tropical-sugar producers in our markets, designed always to protect beet-sugar growers here at home, we have involved ourselves in the political fortunes of other countries in ways that defy any acceptable definition of national interest. These quotas are set largely by the Congress with the aid of some of the best-paid lawyer-lobbyists in Washington.

Expanded trade, not only in agricultural products but in labor-intensive manufactures as well, in the long run not only is to the benefit of both rich and poor countries, but also is the only satisfactory substitute for continued financial dependence by the poor. And without expanded trade, there is no realistic prospect that enough jobs will be created in the poor countries in the seventies to prevent violent social upheavals. Insofar as expanded trade grows out of the Green Revolution itself, it promises to bring greater benefits to the countryside than any amount of financial aid could do.

*Sharing the burdens of overproduction*

Poor countries may find in the seventies that they can effectively divide the rich countries in a confrontation over trade policy. Since World War II, the United States has almost single-handedly assumed responsibility for stabilizing the international market in both wheat and feed grains by diverting a large share of its wheat and feed grain land into nonproductive uses. With almost-certain prospect that global overcapacity in these and other cereals will grow in the seventies, the time has come to ask whether the American farmer and taxpayer should continue to shoulder this burden alone or whether it might be shared with other rich countries, many of which are not contributing to the surpluses.

At an earlier time, the American economy was the only one with the resources to take productive land out of cultivation in order to prevent gluts on the world market. Today, the United States diverts up to 50 million acres, nearly one-seventh of its crop land, for just this purpose. The time has come to ask other countries to assume some of the responsibility in the name of carrying forward the agricultural revolution.

The agenda for the seventies must include a conference, perhaps convened by the World Bank, of all the rich countries, designed to work out a plan for sharing the excess productive capacity. If the trade confrontation between the rich and the poor is to be resolved constructively, this is a minimum necessity, and an urgent one. While governments have been unwilling to do this until now, the problem is becoming too pressing to delay further. The focus of the conference should be on ways of helping the poor countries to enter world markets with their new agricultural production on a competitive basis. The substance of the conference should be a resolution on the part of the rich countries to adopt policies designed to provide food for their people at the lowest price possible.

The mechanics of such a burden-sharing plan would not be difficult. We have had some experience in determining, internationally, the

amount of excess acreage that is being planted each year to a given crop. The amount taken out of production could be prorated among the rich countries, perhaps according to some established formula, such as the one used to determine contributions to international organizations like the World Bank and the International Monetary Fund. Diversion of the excess land to nonproductive uses could be left up to each country. The problem of restructuring world trade in agricultural products is certainly no less urgent for the rich countries, bedeviled as they are by the task of managing inflation without curbing growth. And an agreement to share the burdens of excess cereal production would show a renewed interest on the part of the rich in the problems of the poor, as well as one another's problems.

*An example: Japan and the rice market*

The international rice market provides a good example of the problems and the opportunities involved in trying to share the burden of excess cereal capacity. The world rice market is very sensitive to changes in market conditions. It appears to be headed for a difficult period with the amount of rice available for export at anything approaching a reasonable price almost certain to greatly exceed import needs. The question is what to do about it.

Japan is the only country in a position to avert a major collapse in the world rice market during the seventies. It is the only large, high-income country that consumes rice as its staple food. The United States is already holding a sizable portion of its rice acreage out of production and will probably hold back more in the future, but even so we cannot affect the world situation to the same extent as Japan. With an internal support price of $420 per ton—nearly triple the current world-market price—Japan is perhaps the most serious violator of the laws of comparative advantage of any cereal-producing country. Not only is Japan no longer an importer, but it is now subsidizing exports of rice, thus severely depressing prices in the world market for countries that must make their living from rice exports.

The Japanese rice market, once open to imports from East Asia, is as closed to the outside world today as was Japanese society itself prior to the visit of Admiral Perry a century ago. But rice is the lifeblood of most Asian economies. Should the bottom fall out of the Asian rice market, as the cessation of hostilities in Vietnam brings a reduction in the flow of economic resources into the region, development in Southeast Asia could be seriously set back.

Fortunately, several economic factors in Japan today indicate that the policy of raising internal rise prices ever higher may be nearly bankrupt. Inflationary forces, spurred in part by rising rice prices, are becoming stronger. Unemployment is virtually nonexistent and labor shortages are acute. The labor situation could assume crisis proportions owing to the record number of new jobs created by a sustained economic growth rate of more than 10 percent yearly, and to an imminent precipitous decline in the number of young people entering the labor force as a result of a sharp drop in birth rates during the early fifties. The alternatives might then be to liberalize farm policies, releasing some of the sizable farm-labor force for non-farm employment, or to import labor from other East Asian countries. One can hope that Japan will opt for the former course.

Japan's great and growing stake in trade and investment in Southeast Asia is also a reason for hoping that Japan can be persuaded to take the lead in sharing the burden of excess rice capacity. The countries of Southeast Asia are precisely the ones that should be exporting rice to Japan, and each currently has a large trade deficit with Japan. This is a classic example of how countries can benefit from trade liberalization. Japanese payment for rice imports from the East Asian countries would enable them to buy more of Japan's industrial products, and Japanese consumers would benefit from cheaper rice.

The United States has little leverage over Japanese policies at this time. We want and need Japan as an active political and eventually military partner in East and Southeast Asia, but the Japanese are warning us that neither is possible in the immediate future. The Japanese are looking for a new relationship with us to replace one that they have come to regard as subservient. Even trade relations between our two countries have become strained as a result.

An appeal to national self-interest might succeed in persuading Japan to share the burden of excess rice capacity. The Japanese do not want to rearm; they would rather conduct their relations with their Asian neighbors by expanding trade and assisting regional development. Japan could make no greater single contribution to these ends than to assume primary responsibility for stabilizing the world rice market. And surely, such a step would serve American and Japanese interests better than pressing Japan to rearm.

### X. REORDERING NATIONAL PRIORITIES

It would be nice to be able to conclude that all that is necessary to sustain the momentum of the agricultural revolution is for the United States to persuade Japan and Europe to shift their priorities away from agricultural protection toward providing food at the least possible cost. But the real weight of the agenda for the seventies must rest upon the United States. Many nations are rich enough to follow our lead, but none is rich enough or big enough to take the leadership itself.

The American people are in a period of deep soul-searching. Discussion in the press and in the Congress reflects widespread concern over national priorities. The Vietnam war is just one reason for this concern; the problems of our cities and of our minority groups are the problems of a society that has grown very rich but is still in many ways undeveloped. These are fundamental causes of our discontent.

There seems to be growing consensus that we have been spending too much on "foreign policy" as opposed to "domestic policy." Adherents of this view cite the fact that $82 billion in the current federal budget is appropriated to maintain a vast armed force, to encourage weapons development, and to maintain a network of some 400 military installations abroad. However, it is less well known and more frequently ignored that we are spending only $3 billion on economic and technical assistance and on food aid. Even this figure is declining. Any reassessment of foreign policy should start with an exploration of the allocation of resources to our role as world policeman as opposed to our role in world development. Insofar as the Vietnam war has blurred the distinction between these two roles, it

has made a reassessment of national priorities in the foreign-policy area infinitely more difficult.

We cannot ignore the demands of our security in a turbulent world. But this does not mean spending more; it may mean spending a great deal less. We must begin with some definition of our role in the world that fits our national interests, bearing in mind that it is becoming more and more difficult to separate the national from the global interest. This division of resources must be more consistent with the world as it is in the seventies than with the world as it was in the cold war era, an era that lasted through the sixties, long after the Communist monolith as such had ceased to exist.

Our foreign policy, our relations with the world of today, must recognize that the future threat to peace and stability is increasingly poverty, not Communism. The opportunities to fulfill our role as a participant in world development will be much greater in the seventies than in the sixties. At the same time, the need to fulfill the policeman's role could be much less, particularly if we fulfill the development role.

In large part, the new opportunities grow out of the agricultural revolution. Just as in the sixties we learned how to help others expand food production, so in the seventies we can learn to help others create jobs. But this will take more resources for aid, not less.

For many years, the conventional rule for determining a just contribution of public assistance and private investment to world development from the rich countries has been 1 percent of GNP. The Pearson Commission, in reaffirming this objective, argued that 70 percent of that contribution should be in the form of official aid. That would require, for the United States, a foreign-aid contribution on the order of $8 to $10 billion a year during the seventies, at least double today's level.

There are many ways in which such a contribution could be made: through bilateral programs, multilateral development institutions, trade and investment subsidies, and the like. But these are details. The first question in reordering national priorities in foreign policy should be: Can the United States and the other rich nations continue to progress and prosper in a world in which the gap between rich and poor is rapidly widening, and in which the rich are becoming an ever-smaller minority? Surely the answer can only be no. The problems in the poor countries—hunger, unemployment, technological change, and attendant social turmoil—are sufficiently akin to our own problems to command at least this financial expression of our concern. Perhaps if we had not done so much to master the problems of food production, we could conclude otherwise. But we succeeded, and we must live with our success. Now, the clamor for jobs is replacing the clamor for food. If we do not persevere, the successes of the past will be quickly undone.

The significance of the breakthrough in cereal production goes far beyond agriculture. It is meaningful because it represents at least the beginning of a solution to the problem of hunger, which until recently was regarded as nearly insoluble.

Only a few years ago, it was considered highly unlikely, if not impossible, that most of the additional food needed would be produced in the hungry countries themselves. Farmers were largely illiterate,

widely dispersed geographically, and apparently not susceptible to new ideas. Yet the breakthrough occurred. We learned to combine policies and technologies, and got agriculture moving.

The problem now is to keep it moving. Otherwise, the farm breakthrough will aggravate the job shortage and accelerate the exodus from the countryside to the already overcrowded cities.

The agricultural breakthrough is significant, not just for itself, but because of the possibility it raises of transferring new techniques and technologies in other areas, such as education and family planning. Recent advances in the rice paddies and wheat fields of the poor countries may usher in a new era in international development as well as in world agriculture.

Thus the new seeds promise to improve the well-being of more people in a shorter time than any other single technological advance in history. They are replacing disappointment and despair with hope. For literally hundreds of millions, they can be the key to the door opening into the twentieth century. But that door will open only if a sustained effort is mounted by the rich and poor countries together.

Mr. BROOMFIELD. Thank you very much, Mr. Brown, for those interesting observations. I would like to make one observation, that I don't question this idea that we have got to rearrange our priorities, I think it also holds true that other developing nations around the world have the responsibility, too, and I think if we once can get some of these other countries to assume some of the military portions of defense of the world, we will be a lot better off.

I think that this is a two-way street. I think everybody has their proportionate responsibilities. We have got them in our own country, too. I want to introduce what I consider one of the finest Members of Congress in the agricultural field, one of the experts that many of us look to, and that is Paul Findley, to introduce the panelist.

Paul?

Mr. FINDLEY. Thank you very much, Bill. I hope everyone here today has taken note of the fact that both Mr. Brown and myself chose suits which are in keeping with the theme of the day, the Green Revolution.

Taking advantage of my opportunity here, I will express the hope that before our discussion is over, in addition to expressing some agreement with Dr. Brown's comments, I hope his suggestions about more supply-management here at home, and in the international field in terms of individual commodities will be challenged by someone, and I will stand by in case I am needed.

## INTRODUCTION OF DR. BERNSTEIN

We have three on the Panel today. The first gentleman is Joel Bernstein. Because the clock hand is moving around so rapidly, I won't read all that I am sure is in front of you in the way of a biography, but I believe that Dr. Bernstein is living proof that there is continuity in our AID program.

If he had not been with AID since the year 1, he has at least been there since the year 2, or 3. His experience in this program covers 21 years.

We are glad that the program has been continuous all of these years, and that even though it has not been authorized for the multi-year periods, which many people would like to see done, myself included, it has indeed attracted some first-class people and kept them. Dr. Bernstein is an example of that group.

INTRODUCTION OF MR. DENNISON

The second man on the panel is Charles S. Dennison, vice president of the International Minerals & Chemicals Corp. He is a member of the President's Science Advisory Committee Panel on World Food Supply, a trustee of the Agricultural Development Council, and has had wide experience in management and trade on the international level.

INTRODUCTION OF DR. PADDOCK

The third member of the Panel is one very familiar to members of the House Foreign Affairs Committee, because copies of his challenging book, "Famine 1975!" were distributed to each member of the committee during our consideration of the foreign aid bill about 2 years ago.

This provoked a lot of interest and discussion. He and his brother have authored not only that book but a book entitled "Hungry Nations."

Dr. William Paddock has been the source of advice and counsel and, I am sure that we will all find his ideas challenging and somewhat different in their thrust than some of those expressed here today.

I guess, Mr. Chairman, you wish the Panel members introduced in the order in which they appear on the Panel. So I will turn first to Dr. Bernstein.

Mr. ZABLOCKI. Thank you, Mr. Findley.

You may proceed, Dr. Bernstein.

Mr. FINDLEY. Thank you, Mr. Chairman.

## STATEMENT OF DR. JOEL BERNSTEIN, ASSISTANT ADMINISTRATOR, AGENCY FOR INTERNATIONAL DEVELOPMENT, WASHINGTON, D.C.

Mr. BERNSTEIN. Thank you, Mr. Congressman, and members of the committee, the symposium, and ladies and gentlemen.

Mr. Findley, when I joined this program in 1948 in Europe where I was when it started, it seemed to me that it would be a very good thing to do for a year.

But I must say, and I think that this is true of others, that as opportunities have arisen to do other things, when we ask ourselves how we will feel in terms of the personal satisfactions, it is hard to make the shift.

I think that says something about the program itself, despite the many problems, occasional frustrations and so forth.

KEY ROLE OF AGRICULTURAL TRADE POLICIES

Mr. Chairman, turning to Mr. Brown's presentation, I would agree with his stress on the key role that the agricultural trade policies of

the developed countries must play in carrying forward in the seventies the positive developmental results of the Green Revolution.

These policies will determine, perhaps more more than anything, whether the potential gains will be realized. The potential gains include lower cost food, and therefore, higher living standards for poor people in the developing and developed countries.

They include shifting of productive resources from uneconomic uses in high cost agricultural production to uses that will contribute more to national welfare, and an accompanying mutually enriching expansion of trade between the rich and poor countries.

They include reduction of the inflation that has plagued developed and developing nations. And they include the social and political gains to which Mr. Brown and earlier speakers have referred.

At the same time, the new economic prospects opened by the Green Revolution call for vigorous actions in the developing countries if the potential gains are to be fully realized—actions along lines that have been brought out by the other speakers.

Helping to induce and support appropriate action there is, of course, the concern of our economic assistance programs and of the multilateral assistance programs that we support.

Much can be done to further three closely linked developments, already discussed in some detail, that will simultaneously increase developing country welfare and reduce the scope of the worldwide adjustment problems viz:

Increasing the effective demand for gain in the developing countries;

Diversifying their agriculture and;

Improving the nutritional quality of their diets.

### JOB AND LABOR-INTENSIVE FARMING

I agree with Mr. Brown and others' observations that the key to higher effective demand for food is more jobs in the developing countries to produce higher income. Some increased rural demand for food is self-generated by higher production. But the major income and job increases must come from developing more labor intensive types of agriculture including production of high protein crops, and livestock, from increased rural public works such as local irrigation and drainage facilities and farm to market roads, and from the expansion of nonagricultural employment.

Moreover, a rapid expansion of new jobs will be needed simply to avoid the tremendous social and political disruption of rapidly rising unemployment as the developing countries face the prospect in the 1970's of a rapid increase in the annual number of new entrants to the labor force.

It is estimated that during the decade of the seventies, the net increase in the labor force of the less developed countries (excluding mainland China) will be about 165 million—a 25-percent increase over the estimated 1970 labor force of about 650 million.

This compares to an estimated 117 million net increase in the labor force in the 1960's. The same projections anticipate a net labor force increase in these developing countries of about 525 million in the two decades 1980–2000.

Those who will enter the labor force in the 1970's are already born, so that programs to reduce the rate of population increase cannot affect this employment problem during the next decade.

### BUILDING BETTER MARKETING LINKS

Measures are also needed to build better marketing links between food on the farm and in consumer's hands. These have a dual effect in increasing effective demand for the increased output from the Green Revolution. They provide access to larger markets and also create jobs and income that increase total demand for food. Here is a major role for the private sector. Some of my colleagues on this Panel may wish to discuss further the possibilities and benefits of action in this sphere.

Action along the various lines that I have indicated will also help deal with another problem emerging from the Green Revolution—the fact that large masses of farmers are being left out of the production advance, particularly small farmers and those in physically less favored areas.

Unless something is done to enable them to participate more fully in expanded rural production, their relative position will grow worse and perhaps even their absolute position.

This could spell much trouble. The labor creating activities that I have stressed particularly favor the small farmers. Other measures needed are to steer technological advances in directions that will help the farmers left behind; e.g., by developing improved crop varieties and practices that they can apply, and to improve the extension co-op credit complex that is needed to support more effective participation in agricultural advances by small farmers.

Moreover, as others have brought out, the developing countries need a much greater capability to develop agricultural technology suited to their local requirements if they are to sustain the forward thrust of the Green Revolution. And finally, they need well-trained people to discharge the many functions that I have mentioned.

The types of action to help farmers to which I have referred will also help to moderate still another problem that may reach critical proportions in the 1970's—the extremely rapid and helter-skelter growth of cities in the developing countries. I will not attempt to discuss that problem today, except to note that it will require much attention from development assistance agencies.

### NO TRUE GRAIN SURPLUSES

While there may well be serious problems in the 1970's in achieving orderly marketing of rapidly expanding grain production, if we take a little longer view we must recognize that we are not really able to envisage true grain surpluses—at least not yet.

First, there is the present hunger problem to overcome, as Mr. Brown and others have stressed. But we all know that there will also be an unprecedented increase in mouths to feed—about 25 percent more by the end of the century.

And that is not all. At higher per capita income levels, the average food grain consumption of the world's population will be higher than

at present, if the food is available, and there will be great increases in grains fed to livestock.

All this does not, however, detract from the urgency of the world trade policy problems that Mr. Brown has highlighted. To realize the potential for expanded domestic production and use of grain will require that a modest proportion be exported to earn foreign exchange needed to sustain a high rate of overall economic growth.

So the answer is not simply greater domestic use. Unless world trade patterns in grains and other agricultural products can be rationalized over the next decade, the expansion of production and income in the developing countries will be held back seriously, less progress will be made in reducing world hunger problems, international tensions will be exacerbated, and the exports and real income of the developed countries will also be less.

### NEEDS OF THE FUTURE

To sum up the needs of the future, as expressed thus far, we have observed that the developing countries need to—

Sustain the agricultural production momentum of the Green Revolution, as an indispensable component of their overall development;

Diversify and rationalize their agricultural production patterns, in harmony with a rationalization of world trade patterns in agricultural commodities;

Greatly accelerate the creation of new jobs as an integral part of the foregoing developments (and also outside the rural economy);

Strengthen their capacity to generate technology, trained people, farmer service institutions, and suitable rural development strategies to support the foregoing trends.

Mr. Chairman, in thinking about the future, it is appropriate to recognize that these are all needs that can be addressed in varying degrees by our development assistance programs, wherever the responsible authorities in the developing countries are making a strong self-help effort and want our assistance.

### AID'S CONTRIBUTION TO AGRICULTURE

As you know AID and its predecessor agencies have always put heavy stress on the development of agriculture. In the 5 most recent years, 1965–69, direct AID assistance to agriculture has been $2.5 billion or about 24 percent of the total program.

Moreover, agricultural growth is dependent on development of the economic infrastructure and other economic sectors supported by AID's program.

Out of $63 million approved for research projects over the period 1965–68, $23 million or 36 percent went for agricultural research. In fiscal year 1969 AID has 57 agricultural projects being implemented by U.S. universities, representing 30 percent of the total value of the Agency's university contracts.

With hindsight and the benefit of experience, we can see that this assistance often was not as effective as it could be. But much of it was

highly effective in building the institutions and trained manpower that are indispensable for sustained agricultural programs.

There is a connection, for example, between the programs of AID and other assistance agencies, and the estimated 28-percent higher grain yields in the developing nations in 1967 compared to the 1948–52 average, not to speak of the yield jumps since then.

Now we know how to do better.

### AID REORGANIZATION: TECHNICAL ASSISTANCE BUREAU

The Agency has recently undergone some reorganization in order to—

Increase its ability to identify the key problem areas impeding broad-scale advance, in agriculture and other critical sectors, for developing country growth and modernization;

Mobilize the best U.S. brainpower and experience to work in depth on these key problem areas;

Follow through with the necessary problem solving activities over the timespan needed to get effective results.

That is the core task of AID's new Technical Assistance Bureau. We also hope to apply our experience in technical assistance so as to improve agency methods of working with outside organizations who carry out projects for us, and with our colleagues in the public and private sectors in the developing countries.

The need for continuity of approach and sufficiently longtime perspective in planning and implementing technical assistance activities has been stressed in just about every study of this subject, much as it has been stressed here today. These are needed not only to design and execute sound activities, but also to justify the investments in building the knowledge and personnel capabilities that are essential for good technical assistance work.

To be effective, technical assistance must influence the attitudes, perceptions, motivations, and ways of doing things of the peoples of the developing countries. It must help them to create new and lasting institutional capabilities that will enable them to perform for themselves the developmental functions that are essential for their own progress.

This is a complex and long-term task. It cannot be done well on a short tether, or when beset by the intrusion of short-term political factors.

### SUGGESTED GOVERNMENT ACTION

Thus, to pick up the themes introduced earlier by Mr. Freeman, Dr. Hardin, and Dr. Mosher, I would make the personal suggestion that your symposium lead to a recommendation to the Congress and administration that development assistance be provided with a legislative and executive base that recognizes it for what it is—a highly demanding professional activity essential to the U.S. interests in the establishment of a compatible world environment, that requires a stable and long-term legislative and organizational mandate. . . .

With such a mandate, Mr. Chairman, we could improve our contribution to ameliorating the problems of the 1970's discussed today, and to the broader range of purposes of our development assistance program.

Thank you.

Mr. FINDLEY. Thank you very much, Dr. Bernstein.

One small, but I think, notable, step toward that goal was the establishment of the agency that you now head, the Bureau for Technical Assistance.

I think it does show some increased and proper recognition for this responsibility and I congratulate you on the leadership you are giving that new Bureau.

Next, Mr. Charles S. Dennison, vice president of International Minerals & Chemicals Corp.

## STATEMENT OF CHARLES S. DENNISON, VICE PRESIDENT, INTERNATIONAL MINERALS & CHEMICALS CORP., NEW YORK, N.Y.

Mr. DENNISON. Mr. Chairman, I open by referring to Lester Brown's talk about priorities. I know this House and its sister body are examining the Nation's role in world affairs. I submit that when we consider how the United States exercises its power we immediately think of force as the ultimate expression of power. There is an option to force, an option that does not replace force but can supplement it effectively in foreign policy. That option is the exercise of power by peaceful example, by influence, by accomplishment.

At this rather sad moment of history, when by a vicious irony of fate our national character is darkened by the Songmy incident, the Nation might well examine the importance of this policy option.

The Green Revolution and all that went into it expresses that option. It is creative and it is making a major contribution to one of man's most aggravating problems. It expresses the best of the Nation. The moral authority of the United States is an imperative of world order, not because of any chauvinistic thrust, but simply because there is no one else to exercise it.

Therefore, I believe that the best side of the Nation, the side that expresses its creative genius, is represented by the Green Revolution and the many things that we have been discussing today. I submit, Mr. Chairman, that this is a most important element in American foreign policy.

Moving from policy, one point that has emerged clearly during today's seminar is the nature of our splendid pluralistic society. We have seen that the Green Revolution is the result of a productive interplay between science, private foundations, legislation of this Congress, industry, and educational institutions—in effect, of the Nation.

I hope we keep in mind that it is this interplay, this freedom to act on a proper course, this sense of duty, which gives the Nation much of its strength.

My specific area of interest is the one that Prof. Ray Goldberg inventively called agribusiness some years past. I will touch on it briefly.

### THE LIMITS OF AGRIBUSINESS ACTIVITY

First, I must call attention sharply to the limits of agribusiness activity. There has been a tendency to assume that the agribusiness community, which has been so effective in the United States, can auto-

matically play a similar role about the world. Possibly it can, in due course. It is doubtful if it will in the short term. One of the immediate reasons is that the private sector depends upon profitability for its performance, and agriculture in the developing nations has not been that profitable.

The Green Revolution introduces a new element of productive potential, but the caution stands. Agribusiness is not a shortcut and its role must be examined carefully.

In questioning the role of agribusiness it is clear that the various private communities of business, the social scientists, the physical and natural scientists, must work together. As a sort of nonprofessional urchin from the private sector I meet frequently with my friends and colleagues in learned groups. I often discover that they are deeply engaged in matters that are of critical importance to what we in the private industry are trying to do. But we do not talk to each other as a matter of course. This is not deliberate, it is accidental, and I believe it must be overcome. In specific terms, what we heard today about the Green Revolution was the result of what the natural scientists achieved in plant genetics and what the social scientists have been programing and teaching. As a final step, agribusiness may come in with the investment and management and market building that are necessary to make the whole system ultimately effective.

### THE AGRIBUSINESS COUNCIL WORK IN PAKISTAN

I am now going to be quite specific, as people in my role are expected to be. I will give several examples of how agribusiness has been working in an intercommunity sense. The first concerns the Agribusiness Council which has been working in Pakistan in a joint effort with the Pakistan Government, with the foundations, and AID, to try to get a fix on what the Green Revolution has brought to that country in both wheat and rice.

The Council's approach was to get a multidisciplinary group of specialists from the foundations, and AID, and the Pakistan Government, to work with industry experts concerned with inputs, transportation, mechanization, and the offtake and distribution of increased farm output. In this latter area an expert from an international grain trading company was involved; going right to the point made by Lester Brown that we are facing a new dimension of world trade in grains. No longer can you talk simply about a fertilizer plant, a tractor plant, or a pesticides plant. You must talk about the entire system. The ultimate objective must be the market for agricultural production, both international and national. It was mentioned earlier today that East Pakistan is short of grain despite increased output. It certainly is. The stuff is drying and rotting in the field while people are hungry in other areas because of inadequate movement, storage, and distribution.

In the case of the Pakistan study the intercommunity group spent the past summer identifying the problems that exist in present wheat and rice production and indicating areas where private investment could be brought in—largely local private investment—to speed up the process and make it more viable. The study group also examined

the possibilities of crop diversification by shifting from rice and wheat to seed oils, cotton, vegetables, and cattle. This, then, was a pilot effort by the agribusiness community in working with other groups to get at the problems and the potentials of the Green Revolution in a major producing country.

### COOPERATION WITH FAO AND UNDP

There is another agribusiness effort underway at the FAO and the UNDP. When Doctor Sen was head of the FAO he invited international industry to consult with his organization. A committee of major corporations from both sides of the Atlantic and Japan was established. They sought ways for the private sector to advise the FAO on how to get the market approach into country economic studies. This cooperative work has since been extended to the UNDP and is now also being made available to other specialized agencies.

If a country is interested in attracting private investment—and this obviously excludes countries like Egypt, Burma, et cetera, it is very helpful to have private industry experts involved in preinvestment surveys. Against the hard tests of the marketplace and of return on investment they can specify that a project will not pay out—and they can do so early in the game.

This type of expert assistance can now be made available to the international agencies where it is wanted by seconding people from international industry or using them as consultants to insure that these preinvestment studies have ultimate viability.

This is another example of how the agribusiness community can work with other communities and institutions.

Within the receiving countries there is a need for agribusiness to perform new roles. We listened to Dean Lewis' fascinating views of what has happened in India. I recall a day when I sat next to the good Dean in a monsoon while we were dedicating a major fertilizer plant in Andhra Pradesh. Water was pouring through an umbrella onto his knee, and as a representative of the host I didn't think that a minister of the U.S. Government should get that wet. So I put a pad of notes over his knee to limit the water damage.

### PROBLEMS IN BEING "ENGINE OF CHANGE"

When you commission and operate a major fertilizer plant such as the one we were dedicating, you really test the local economic system. I have been asked what happens when you run into a backward environment with such a complex operation, and I respond that you lose your religion and your purse. But you do test the system.

Each time the international or even the local investor brings in an industrial "engine of change" he must cope with the local environment, with power supply, with water, with railroad wagons, with harbor facilities, with the total infrastructure support. He also must cope with the available farm credit and the crop offtake system.

It is not an easy job. Anyone who has the notion that the Green Revolution is going to proceed easily in a country like India in rice, is wrong. At this moment there are huge tonnages of fertilizer stocked

in India because supplies were obtained on the basis of calculated need instead of effective demand.

Getting down to local distribution, to the cultivator, you must work with a large network of small, local enterprises who stock, demonstrate, and sell the fertilizer. That is a punishing task. While farm credit has been discussed in the halls of governments and universities about the world, it is not available in adequate quantity to the marginal and smaller farmers in the villages. It is not available in India, it is not available in Indonesia, it is not available in Thailand. It is not available in adequate amounts in any of the countries involved in the Green Revolution.

If we are going to bring farmers into the main stream of the agricultural revolution, significant work on farm credit and crop distribution must be done. Unfortunately you cannot force this development from the national capital nor from abroad because the networks of banking institutions do not reach out into the villages, for it has not been profitable to work with the locals. This must be done and it will take a long time. For this reason together with the problems involved in processing and moving increased crops, India today has an almost embarrassing stock of fertilizer because of relatively limited demand in the face of immense need.

This then is a caution. To get at this question and others within the developing countries it is necessary to pool resources, to associate agribusiness with the other communities concerned. I believe it would be most useful to create agribusiness councils parallel to the one we have in the United States as a means of consciously bringing the scientists, the foundation specialists, the social scientists, and the agribusiness managers into regular consultation. If they could meet at least four times a year to assess developments in the agricultural revolution they could grapple with existing problems and, more significantly, anticipate developments and constraints.

As we have learned today, there are factors in the Green Revolution that are beyond the sheer calculation of the marketplace: Factors of increasing rural employment, of accelerating mechanization, factors of nutrition and other matters that simply don't yield to normal business analyses. I think that most management today, given the opportunity to examine these pressing social questions with experts, would be willing to do so and at least to try to make business decisions that serve these larger social purposes.

### NEED FOR INSTITUTIONS OF MANAGEMENT TRAINING

Such an anticipatory enterprise can only be achieved by conscious effort and intercommunity collaboration. We have heard today about the four splendid international research institutions in agriculture which have been sponsored by the foundations. I submit that we need parallel institutions of management, perhaps two to start and eventually four or more. I am not using management to mean the skill of a businessman who keeps the books and makes dough. I am using management as the instrument for analyzing, planning, programing, mustering resources, operating and controlling ventures or systems. Robert McNamara is a manager at the World Bank. There are managers all

through Government, in hospital systems, in educational complexes as well as in industry. Management as a science, if you will.

Peter Drucker, who is something of the guru in this field, has said there are no underdeveloped countries—there are only undermanaged countries. He has a point, and there is clearly a pressing need for effective managers in the developing world.

When you bring an engine of change into a backward community as I described earlier, you provide a relatively modern set of management tools and capabilities. If you have an 18th century government apparatus to receive this engine, you have a bad situation indeed. The locals do not know what you are talking about or trying to do. There is waste of time, of money, and there is conflict.

To meet this technological impact it is necessary to improve the receptivity of the host government locally and nationally by deliberate training of personnel in the management of development. Trained managers can, with their ability to get things done, be it in the public sector or the private sector, grasp the innovations made by the physical and natural scientists and put them to work effectively. I therefore make a strong plea for the establishment of international centers of excellence in management, supplementing those in agricultural research. These centers should of course be located in the developing countries, for the job must be done there—not here.

### OPPORTUNITY FOR THE PETERSON TASK FORCE

To close, Mr. Chairman, I believe that U.S. foreign policy and U.S. influence are closely involved in the type of effort represented by the Green Revolution, and it should be supported.

I believe that private investment in agriculture is limited in its total impact, but it can play a constructive role, particularly if investors have patience and if we work with our colleagues in other disciplines.

Management is a vital tool and should be developed along with agricultural research.

I close by saying that in 1970 the Peterson task force offers the Nation an opportunity to reconstitute its on-going foreign assistance effort. I must emphasize that there would be scarcely any investment if it were not for the infrastructure, the education, the training, and the support provided by our aid programs. We certainly would not be in India, and very few investors would be in any of the underdeveloped countries were it not for our effort at economic assistance.

This is an important time for all of us to regroup our forces and to build on the Green Revolution and on other successes in economic development. I hope the Congress will stay the course and provide the long-term mandate required for international economic development. This is an appropriate objective for a nation that approaches its bicentennial in 1976.

Mr. FINDLEY. Thank you.

I am sure that everyone here has been impressed, as I have been, with the consistently high quality presentation. The applause, Mr. Dennison, shows the favorable reaction that your suggestions gave generated.

I am sure the final speaker will be no exception. Dr. Paddock is well known to AID. He is also well known throughout the agribusiness world as well as known here on the Hill. So we welcome you, Dr. Paddock.

## STATEMENT OF WILLIAM C. PADDOCK, CONSULTANT ON TROPICAL AGRICULTURE, WASHINGTON, D.C.

Dr. PADDOCK. Thank you, Mr. Findley.

Mr. Chairman, ladies and gentlemen, it is a pleasure to be here today. Dr. Brown and I used to walk, locked stepped, in our outlook on the world food problem.

But as has been said, Dr. Brown turned "Green," and you see what color suit I am wearing.

There are three things in Dr. Brown's paper on which I would like to comment. The first one is the emphasis on the high yielding varieties in the Green Revolution. The second is his point that the problems of the seventies will probably be more political than technological. And, finally, the need to readjust our own foreign trade policies to serve, or to further, the Green Revolution.

On the importance of the high yielding varieties, I would like to reemphasize the other factors involved in increased yields.

### WEATHER FACTOR IN FOOD INCREASES

Secretary Hardin mentioned weather. We tend to overlook the fact that the weather in the last couple of years has been very good in most of the developing world's agricultural regions.

There are many ways to measure the good weather. It has not been just wheat and rice—the wonder wheats and the miracle rice—that have increased production. For instance, in India there has been a 20- to 25-percent increase in peanut production, jute, coffee, rubber, millet, a whole series of things.

Figures coming out of Red China, and who knows whether they are right or wrong, indicate that without the new varieties that country is nevertheless keeping abreast of India in its production.

All of this implies that much of the increase in production is coming from a generally good agricultural situation and its cause is good weather for the farmer.

The Green Revolution is limited in scope. In the case of India, when you speak of the Green Revolution, you are speaking of only wheat, not rice. Unfortunately, wheat is a far less important crop than rice; it amounts to only a third of India's rice production.

Rice production today in India is essentially the same as it was in 1964–65.

### IRRIGATION IS THE "LIFEBLOOD" OF THE GREEN REVOLUTION

When one speaks of the increase in wheat production due to the Green Revolution one needs to emphasize the role of irrigation. For those who have only seen wheat grown in the United States, where it is never irrigated, this essential point is usually missed.

When we say water is needed for the new wheat varieties, we mean irrigation; that is, using the most expensive, the most valuable land in the Nation. We are speaking only of irrigated wheat.

Irrigation is the lifeblood of the Green Revolution. This irrigated land is, of course, limited in quantity. Dr. Hardin said this morning that if you look at a map to see where the Green Revolution has had an effect in the world, you will see a postage size area and no more. The major reason for this is the limited amount of irrigated land in this world.

## SUBSIDIES HAVE STIMULATED PRODUCTION

The final point about the high yielding varieties I would like to make involves subsidies. Dr. Brown mentioned Japan having a subsidy for rice three times that of the world market price. As far as wheat is concerned the United States has a support price that perhaps is slightly above the world market price, depending on how you figure the U.S. support. Western Europe does, too. But what is good for one nation is not necessarily good for all. Mexico has a wheat support price of $1.99 a bushel, while the world market price is something like $1.45 a bushel. So it is 40 percent above the world market price. Obviously, Mexico does not want to export wheat on such a basis for it is clearly a money losing proposition.

India and Pakistan also have supported the price of wheat and it is now about $2.60 a bushel. Turkey supports the price at $2.30.

Dr. Paarlberg says that surpluses follow subsidies like night follows day. If one raises the price high enough on a commodity, a surplus will follow whether it be uranium, or diamonds, or gold, or rutabagas, or wheat, or rice.

Within a year of the Philippines announcing its policy for self-sufficiency, that country increased the rice support price by 50 percent. The result was an increase in rice production.

But these subsidies must become a serious burden to the developing world. The United States can afford a $4 billion agricultural subsidy program because agriculture contributes only 4 percent to our GNP.

The rest of the U.S. economy—the other 96 percent—can carry the load. When agriculture, in the case of the developing countries, accounts for 18, 25, 30, or 50 percent of the GNP, then subsidies will certainly become a financial burden and will eventually have to be adjusted downward.

If you lower the price most people will agree that production will fall accordingly.

## MANY TECHNOLOGICAL PROBLEMS AHEAD

Therefore, the Green Revolution's technology that we are talking about here today, that is these highly yielding varieties, is not good enough to stand by itself. It must be subsidized. There is then an enormous need for better technology if the Green Revolution is to survive.

We have got to find some way for these new varieties to be improved still further if they are to be used without the high prices that now go along with them.

Therefore, I would see the 1970's as a period when there will be continuing political problems. But I think that the technological problems that still have to be solved in the 1970's are probably even greater than those that have already been solved.

For instance, we have to find out how to break out of the limits imposed by irrigated land. It will be more difficult to move ahead with corn and rice than with wheat. It will be more difficult to achieve in the tropics the progress that has already been achieved in temperate zone India, Pakistan, and Mexico. The Green Revolution has had little effect in the tropics. Africa and Latin America still do not know what it is.

Finally, on Dr. Brown's point involving reexamining our national priorities, and trying to assume a global effort to eradicate hunger, I would suggest that perhaps it is premature on the basis of what we know about the Green Revolution to consider changing, for instance, our trade policies, in order to further the Green Revolution. I say this because so much additionally must be done besides just, for instance, changing our trade policy.

### COST OF ENDING HUNGER WORLDWIDE

Dr. Jean Mayer said earlier this week that to eliminate hunger in the United States will require annually an additional $3.5 billion in this country's budget.

If it will cost that in this country, imagine what the cost will be in the rest of the world!

The President's Science Advisory Committee in 1967 said that to satisfy the world's food needs will require annually an additional $12 billion above and beyond what was being spent in foreign assistance throughout the world. A couple of months ago, the Pearson report, written for the World Bank, suggested a figure reasonably similar: $10 billion or more a year. Next June, the FAO will release the Indicative World Plan which calls for an additional $110 billion to be spent over the next 15 years. I have just seen a recent report where the British economist, Barbara Ward, has said the job will require about $10 billion a year.

So there is going to have to be, I think, a great deal more achievement in the Green Revolution and from world governments a greater willingness to contribute to it, before we can talk of eradicating world hunger in the forseeable future.

I fear that overly optimistic reports of the Green Revolution will cause a relaxation on the part of not only the governments of the developing countries toward their own agricultural problems, but that there will be also a relaxation on the part of all those concerned with the world population explosion. Too many feel that the Green Revolution is buying us time to solve the population problem.

I don't see the Green Revolution buying us time.

I feel very strongly that unless it is possible to get this population explosion under control, everything that we have been talking about today is meaningless.

Thank you.

Mr. ZABLOCKI. I think the participants of session 3 discussing the planning for the future of the Green Revolution, Mr. Lester Brown, Mr. Joel Bernstein, Mr. William Paddock, and Mr. Charles Dennison all deserve a good round of applause. [Applause.]

Before I call for questions, may I just say to my colleague from Illinois, like he, I too observed that many have worn green suits.

Many of our observers and guests have either green suits or green dresses or ties or ribbons. Let me say to my colleague, in keeping with today's theme, I too had intended to wear a green tie and reached into the closet just as my wife came by.

It was a beautiful green tie, a Christmas present of some years back, and I wear it at least once a year. She said, "My dear, today is not St. Patrick's Day." Not wanting to be late by having to explain the purpose of the Green Revolution and everything else, and since she already had a tie neatly laid out for me, and being cooperative, I wore what I have on.

I only want to say that the intentions were there, but the spirit weakened.

Are there any questions from the members of the committee?

### NEED FOR EDUCATION IN AGRICULTURE

Mr. FINDLEY. Mr. Chairman, of all the things that have been said today, I believe there has been little comment about education. In my part of Illinois, many good farmers have gone to a college of agriculture and they send their sons to a college of agriculture so that they will be even better farmers. They take part in the extension programs. They have the benefit of continuing research.

My question is, Is enough being done now worldwide to provide the trained manpower needed to meet the Green Revolution's demands?

In other words, are we really laying the groundwork and establishing the educational centers which will turn out enough good farmers to meet the problem?

Mr. ZABLOCKI. Dr. Brown.

Mr. BROWN. One of the things that the Green Revolution has done is to bring into sharp focus the scarcity of training agriculturalists in a number of countries, such as the Philippines and West Pakistan.

### ESSO'S AGRISERVICE CENTER IN THE PHILIPPINES

In the case of Philippines, Esso, which has a fertilizer plant in the Philippines, has organized a distribution system with some 400 agriservice centers where they market not only the fertilizer but all the inputs, seeds, pesticides and equipment and so forth.

It is a one-stop shopping center for a farmer, a very effective system, delivery system.

To man each of these agriservice centers, they try to get a trained agronomist. They were able to compete so effectively salarywise, that the University of Philippines College of Agriculture was losing much of its faculty. It became a national political issue. It was concluded that if too many faculty members were hired away that industrial firms would be biting the hand that fed them. Hence a system

was worked out permitting the recruitment of a certain number from the faculty each year. But this I would think would not be an unusual situation, in a number of developing countries in the future because of the number of trained people in agriculture is going to be in short supply, particularly where agriculture begins to modernize rapidly.

I think one of the significant things is that as agriculture begins to move and really moves ahead, the demands for technical competence and technical assistance increase very rapidly. When you have agriculture that is stagnant, you really don't need any technical advice.

It is when change is occurring that you need this. It is a problem. We are not doing nearly enough to meet this.

### TRAINING PROGRAMS IN U.S. LAND-GRANT SCHOOLS

Mr. LEWIS. I would like to take advantage of the question to fill in one point on my discussion about India. I am particularly happy to do this, because we have some representatives from the institutions I am about to mention here. I see people from Illinois and Missouri at least here.

We were saying earlier that there has, in fact, been a very complex set of inputs, including technical assistance inputs over the years.

Some of them are on a longer leadtime basis, as far as the payoff in the late sixties is concerned. One of the most important inputs and one that AID and its predecessor have had the honor to be associated with is the effort to develop state agriculture universities in India.

This was formalized in the early sixties. There have been first five and then six American land-grant institutions involved. Missouri, Ohio State, Tennessee, Kansas State, Illinois, and Penn State.

It has proven, I think, to be the case that the Indian institutional structure was ready for and indeed needed something rather close to the concept of the land-grant institution.

There are now nine of these State agricultural universities which are turning out a good deal of trained people in agriculture. They are meeting the needs for infrastructure, and are now beginning actually to train farmers in some cases. Furthermore, they constitute a very important component of the applied research network that has begun to work in a really promising fashion.

### BOTTLENECK IN LACK OF TRAINING

Mr. BERNSTEIN. I might add a point.

Let me say first, in response to Mr. Findley's question, that I don't think there has been enough training despite the quantitative effort so far.

This definitely is going to be a bottleneck for the future, despite considerable training efforts. In our own U.S. bilateral programs, which I don't have the figure here of the participants trained in agriculture, I would venture to guess it is in the 30,000 to 40,000 numbers. That is, people who have been brought to this country for advanced training of various kinds in agriculture.

As I mentioned earlier, we have currently 57 agricultural projects being implemented by U.S. universities, the largest part of which are

concerned with training programs similar to the one that John Lewis mentioned for India.

But having said all that about quantity, the key point, I think, is the qualitative question. Are they being trained to do the right things so that they will fit in effectively into the ongoing requirements as the Green Revolution gathers momentum?

I think we would have to say frankly that in the past, many of the people have not fitted in and then it has not been as efficient an effort as we would like to see partly because of the force of traditions in agricultural training, partly because until larger parts of the rural sector really entered the market economy, people were not really sure what they would need to do and how to do and how to be trained for what they need to do.

There wasn't the drawing power needed to direct the training more effectively.

I think, as has been mentioned, you have sort of a self-generating improvement effect growing out of the new opportunities, the new sense of possibility, which has grown out of the Green Revolution, although it is very restrictive in scope, as has been pointed out.

It does point the way to people as to what you need to do for training and education, that it is worthwhile, that young men can get somewhere by making a career in agriculture.

So we are hopeful that if the countries themselves can sustain the effort to train people, with such outside support as they need, that they will begin to do a much better quality job, and I think that part probably will be even more important than the question of numbers.

Mr. ZABLOCKI. Mr. Brown?

### NUMBER OF AGRICULTURISTS TRAINED IN UNITED STATES

Mr. BROWN. We have been speaking somewhat uncertainly about the number of people that we have trained in this country from the developing countries. We have several people here today from the Foreign Training Division in the Department of Agriculture; Dr. Sy Harvey, who is the director of that program. Sy, for the record, how many agriculturalists have we trained since 1950 in this country?

Mr. HARVEY. 43,000.

Mr. BROWN. 1950 through 1969?

Thank you.

Mr. ZABLOCKI. Are there any questions?

Dr. MELLOR. Could I add a brief comment on the matter of university education? I think the rapid agricultural change in India has brought an interesting feature. There is a great increase in demand for technically trained agriculturalists in the private sector of the economy.

I think it is very interesting that what are probably the two best agricultural universities in India, which have been developed very much with American assistance, are now putting a very high proportion of their graduates into the private sector of employment.

If you go back before the Green Revolution practically all of them went into Government employment. I think this is a very significant factor from the point of view of longer term agricultural development.

NATIONAL PRIORITIES

Mr. FRASER. Mr. Chairman, I just wanted again to make a comment about the need for a better ordering of national priorities that several of the speakers developed.

I wanted to make the observation that this is a very concrete question in front of us now. We will have on the floor Monday a cut in military spending of 6 percent or 7 percent, which I think is a pretty fair cut considering the war is still going on.

Tuesday, we will have in front of us a second cut in economic assistance, which if left untouched will mean that the economic assistance request will have been cut from $2.2 billion to approximately $1.1 or $1.2 billion.

The military assistance has been left virtually unchanged. So the question of priorities is a very real and pressing one, not one to be dealt with in abstractions.

I hope the House will change some of these decisions, at least on the economic assistance. But I don't think one can go through this kind of discussion today without acknowledging, as these speakers did, that these decisions are not made in a vacuum.

They must be a part of a larger set of policy decisions which are bearing down very heavily at the moment.

Mr. ZABLOCKI. Are there any questions from the observers? Mr. Wolf?

DISSEMINATION OF SYMPOSIUM PROCEEDINGS

Mr. WOLF. I am a former colleague of my distinguished chairman, Mr. Zablocki. I would like to say that nothing that has been said here today will make me sleep better tonight.

We think about different things in the light of this discussion. I am concerned about what particular procedure will be followed to multiply the number of listeners who are here and will become able to take advantage of these discussions.

I would like to hear from the chairman if I may, on this. The second thought is it would seem extremely appropriate that you or someone representing this particular symposium would present some portion of the findings of this symposium at the Second World Food Conference, which is scheduled for the Netherlands, the 16th and 30th of June next year.

As you may recall the American Freedom From Hunger Foundation helped to host the original first World Food Congress here in 1963. I would be happy to take whatever steps are necessary to see that this is done in my capacity.

But I would be interested immediately in what steps will be taken to multiply what happened here today.

Mr. ZABLOCKI. The Chair is very happy to advise the gentleman and others gathered here that the hearings and proceedings will be printed, available for wide distribution. As long as there will be demand for the hearings and the testimony, we will have them reprinted.

As to the second suggestion of having a summary or a report of this symposium presented at the World Food Conference, we will have to take that under advisement with the chairman of the full committee.

It is an excellent suggestion, I might say.

If there are not any further questions, the Chair is tempted to recognize some of the very important guests and people present here as observers. At the risk of missing anybody, I hesitate to do so.

However, I would be remiss, I believe, if I would not present at this time Mr. James Grant, the president of the Overseas Development Council, who has been most helpful and whose organization has been most helpful in assisting in this symposium.

Mr. Grant, will you rise and take a bow. [Applause.]

As I had earlier announced, there will be a 25-minute colored film. It will be the informal part of a very informal meeting and symposium.

But before closing, let me say on behalf of the committee, and myself, that we deeply appreciate all of you who have come here today for this symposium, and in particular, we want to thank and extend our appreciation to the participants. They have, as I am sure you will agree with me, presented fine papers, commentaries, and direct answers to the questions that were asked of them.

We sincerely thank you gentlemen.

"A FUTURE FOR RAM"

Now if you do have time, I would like to suggest that as many of you who can remain for the film of "A Future for Ram," a 25-minute colored film depicting village life in India. It focuses on a single farm family, their aspirations and the relation of the Green Revolution to their aspirations.[1]

A sensitive, thought provoking documentary, it points out the cultural, economic and administrative obstacles to the introduction of agricultural technology in traditional societies.

The film recently won the Golden Eagle Award from the Council on International Non-Theatrical events (CINE) in recognition of its suitability for international showing.

It was produced and filmed by Dr. Phillips Foster, professor of agricultural economics at the University of Maryland who spent last year living in the village depicted in "A Future for Ram." Dr. Foster and his wife also wrote the script.

Assisting in the production were other persons associated with the University of Maryland. C. John Sincell, assistant to the director for university relations, did the editing; sitar music was composed and performed by Gaurang B. Yodh, professor of physics; and the narration was done by Priti H. Monteiro, a graduate student in electrical engineering.

I want at this time to say thank you for coming, because I won't have time to say it after the film, I am sure.

Again, we appreciate your attendance here today and wish to thank once again all of our participants for their excellent contributions.

(Film: "A Future for Ram.")

(Whereupon, at 4:33 p.m. the Symposium on Science and Foreign Policy: The Green Revolution, conducted by the House Foreign Affairs Subcommittee on National Security Policy and Scientific Developments was concluded.)

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[1] The script of the film may be found on p. 163 of the appendix.

# APPENDIX I—STATEMENTS SUBMITTED FOR THE RECORD

## STATEMENT OF W. L. KLARMAN, COLLEGE OF AGRICULTURE, UNIVERSITY OF MARYLAND

Hon. CLEMENT J. ZABLOCKI,
*House of Representatives,*
*Washington, D.C.*

SIR: As a botanist, I am vitally concerned about the so-called "Green Revolution", and I applaud all efforts to increase the world food supply. I must, however, register a strong complaint concerning news articles such as the Washington Post's Sunday report of your forthcoming Subcommittee session.

Terms such as "miracle grains" and "green revolution" give a false sense of security to the general public who want to believe that the food supply can keep pace with the exploding population increase. Increased yields of new grains can, at the best, buy only a little time. At worst, new more virulent pathogens that may accompany increased production can easily make the situation more serious than before.

Those of us who attempt to convey the unpopular message that botanists cannot possibly continue to feed the world if present population increases continue, find that those who oppose this view most often cite the type of nebulous optimism found in the announcement of your committee meeting.

If a miracle does exist, it is only that mass starvation has been averted for a little while longer. Please use this reprieve to bring about the only miracle that can possibly save the world, a drastic and immediate reduction in the rate of population increase.

Sincerely,

W. L. KLARMAN,
*Associate Professor, College of Agriculture, University of Maryland,*
*College Park, Md.*

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## STATEMENT OF BUSINESS INTERNATIONAL CORPORATION: PRIVATE ENTERPRISE AND THE WORLD FOOD PROBLEM (SUBMITTED BY KENNETH D. GOTT, EDITOR, BUSINESS INTERNATIONAL)

Why has the international corporation, so often referred to as the "best hope for bringing less developed countries out of backwardness", accomplished so little in the war against hunger? Is it the fault of the corporation, of home governments, or of governments in the developing country? In part the blame is shared by all these institutions.

Investors from developed countries are restricted by their own governments through illiberal import policies, capital export curbs, and high rates of taxation. Small wonder that many decide that the game is not worth the candle.

In the developing country the investor faces major difficulties. Among them:

* the need to train workers, who have no understanding of basic mechanical skills or plant maintenance;
* the need to borrow in a country where capital formation is slight;
* the need to guard against inflation and devaluation;
* the need to fight red tape, and discrimination (and sometimes arbitrary action) against foreigners; and
* the need to operate despite government control on prices, imports, exports, and the transfer of interest and earnings to the parent

Despite these man-made obstacles, a number of international corporations have begun to devote a considerable portion of their resources to solving the food problem, particularly in the area of synthetic foods and additives.

The firms working to solve the problem include CPC International, Monsanto, General Foods, Ralston Purina, Kraftco, Nestle, and General Mills.

A telling problem is the piecemeal approach used by both governments and corporations in dealing with the food problem. There is no question that a regional approach to development can be more effective. But this has not been generally applied to the food problem. There would be innumerable advantages.

For the most part neighboring developing countries farm basiscally the same crops and raw materials: thus their exports are very often competitive. If regional development plans included direction on agriculture, e.g., X country would produce milk cows for a wider market than local consumption; Y country would produce the basic staple such as rice or corn for the area, exports would be complementary instead. With the successful advent of high-yield grains such an approach is practical.

The problem of distribution is critical in the developing countries. While there are a few firms that have organizations that can support introduction of low-cost, high-protein products on a national or regional scale—there are not many. Most of the companies that can manufacture such products, cannot effectively distribute them (even if they could work out a satisfactory marketing approach in packaging and advertising).

Here, too, new methods and approaches need to be tried. In many areas of the world one or two companies have penetrated even the smallest hamlet. This is true of Unilever in parts of Asia and Africa, of Nestle in parts of South America. But the success of a few does not alter the basic fact that the creation of regional markets would greatly reduce distribution obstacles.

New approaches, grounded on cooperative efforts, are necessary to make real strides forward against hunger. What is needed is coordination of corporate effort—a pooling of abilities and resources on the part of corporations that will minimize the risks and enhance the possibilities of rewards. What is desperately needed is reduction or elimination of national barriers to the free movement of goods, men, money, and ideas across national borders.

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STATEMENT OF CHARLES M. HARDIN, DIRECTOR, INTERNATIONAL AGRICULTURAL INSTITUTE, UNIVERSITY OF CALIFORNIA, DAVIS

Congressman CLEMENT J. ZABLOCKI,
*Chairman, Subcommittee on National Security Policy and Scientific Developments, Committee on Foreign Affairs, Congress of the United States, House of Representatives, Washington, D.C.*

DEAR CONGRESSMAN ZABLOCKI: Thank you for your invitation to attend as an observer the symposium/hearing which will be conducted December 5 by the House Foreign Affairs Subcommittee on National Security Policy and Scientific Developments. I shall be unable to attend the meeting, but I wish to avail myself of the opportunity to comment, following your invitation.

I am convinced that we have in the United States an instrument of great potential that has been far from fully utilized to promote technical assistance abroad. I refer to agricultural science which we have institutionalized largely in the colleges of agriculture in the land-grant universities and in the U.S. Department of Agriculture.

In order fully to realize the potentialities of agricultural science and technical assistance, we need some drastic departures in policy. We need especially to use the colleges of agriculture much more effectively than we have hitherto I stress the colleges of agriculture for two reasons. First, they are not only research and extension institutions but teaching institutions and as such the most fitting bases from which we can hope to help the poor countries build those educational institutions which they sorely need. Second, the colleges of agriculture have each dealt with the complexes of agricultural problems that characterize the various states. In California, as in other states, the agricultural scientists cooperate with each other as teams. It is precisely this kind of team approach to complexes of problems that characterize agriculture which we need to help the poor countries establish abroad in their own institutions.

We here in California strongly believe also in long-term service abroad to carry out our technical assistance programs. We propose to model as far as possible on the Rockefeller Foundation's program in Mexico wherein one of the salient characteristics is that the leading figures went to Mexico for long periods so that their professional careers were committed to Mexico—that is where their

professional repuations would inevitably be made. In contrast, particularly for agriculture scientists, the traditional AID contract calling for one or at most two years' service abroad leaves the agricultural professional in precisely the position he has always been in: the work abroad is a sideshow or a diversion and the real theater of his professional contribution and advancement remains at home. At the same time, while we build programs abroad around the career service of such individuals, we must bring them back regularly to the home campus for long enough periods so that they remain part of the home campus and are so looked upon by their colleagues. Indeed, this movement back and forth is essential to one of the necessary goals of the program I am discussing, namely, the refocusing of our colleges of agriculture in part on specific problem developments and mission responsibilities overea.

To achieve the foregoing kind of program, the universities and the colleges themselves will have to make some changes—they will have to change their promotion policies to insure that those scientists working abroad will be treated equitably in matters of promotion and advancement. It addition to this, there must be a regular flow of funds which I think should be provided in grant-in-aid form by something like the Hatch Act of 1889 for agricultural research but for agricultural service abroad. Since the program under discussion is in the national interest, the national government should pay for it fully. At the same time, the universities, the colleges of agriculture, and particularly the individual scientists all need to be able to make their long-term plans and their career commitments against some assurance of a regular flow of funds. As you well know, we are not talking about massive inputs If we could start out with a 20 million dollar appropriation for this purpose and then work up perhaps to 100 million dollars, we could perform miracles.

Although it has not yet been formally announced, we are fortunate here to be on the verge on a ten-year program in soil and water management (or irrigated agriculture) to be carried out in India under the auspices and with the support of the Ford Foundation. This program will be implemented by the University of California and especially, but not exclusively, by the Davis campus. Our program is modeled on the principles expressed above. We have developed a program through the contribution of our own scientists acting jointly with prospective Indian counterparts. Ford Foundation has given valuable advice from time to time and stands by ready to finance the program over a ten-year period with budgetary periods of two years each. We have one of our ablest men, Dr. Bertil A. Krantz, to lead the program. We also have two or three other senior men with considerable reputation who are prepared to go for relatively long periods. Around this nucleus of long-term personnel, we shall build a program which will also make use of short-term personnel. In addition, the Ford Foundation has agreed to bring back each of our long-term persons every other year for one quarter on the Davis campus, during which time they will share again in the research, extension, and educational programs at home.

Finally, if programs of the kind that I have sketched are going to be developed, we shall need special orientation to them on the part of AID. We will need an agreement in AID to devolve responsibility on the colleges and to let them plan and develop programs. There should be insistence on careful reporting, of course. But the essence is to fix responsibility on the colleges and then to give them sufficient discretion to carry out their programs.

The foregoing description of what I think should be done is along lines that I have been urging for some years on the foundations, on the administration of AID, and on various members of the House and Senate. I am delighted to have this opportunity to present the argument at least in written form to you and your subcommittee. Coming from Wisconsin as you do, you are aware, I am sure, of the tremendous potentiality of a first-class college of agriculture. You are probably also aware of the tendency of our rapidly changing society to cause changes in the college of agriculture which will make it less suitable as a resource for building effective programs in the poor countries abroad. I think that it is vital that we preserve our colleges of agriculture, at least for a number of years, in order to draw upon their demonstrated abilities as institutions of applied science to serve as bases for the development of similar institutions in the poorer countries. If there is anything that I can do further to clarify this argument for you or members of your committee, I shall be most happy to do so

Sincerely yours,

CHARLES M. HARDIN,
*Director, International Agricultural Institute,*
*University of California, Davis.*

STATEMENT OF LOUISE NELSON, ASSOCIATE PROFESSOR OF ECONOMICS, DAVIDSON COLLEGE

## DEVELOPMENT OF ENTREPENEURSHIP FOR THE GREEN REVOLUTION

The ability of underdeveloped countries to adapt to the Green Revolution depends upon complex factors. One of the most important of these factors is entrepreneurship, for it sets the upper limits to successful adaptation to the revolution. That entrepreneurship is the scarcest resource in the countries within which the Green Revolution is taking place has been recognized by nearly all those who are responsible for the successes which have been obtained; however, too little emphasis has been placed upon developing the requisite skills for entrepreneurship.

An attempt should be made to harness the forces emanating from the Green Revolution to generate entrepreneurship of a type most suitable, and in areas where it is needed most urgently, namely, within the rural environments. The agri-business centers within these areas, a few of which are beginning to develop, show promise for this purpose In general consideration of the utility of the agri-business centers has led to emphasis upon their potential for providing adequate non-farm employment opportunities for excess agricultural labor and for providing income to support markets for increasing supplies of food. The potential in these centers for development of entrepreneurship has usually been neglected.

At the same time it has been fully recognized that facilities for marketing, storing, and processing agricultural products are inadequate or absent, and that credit facilities through which small-scale producers, may acquire seed and fertilizer do not exist in most areas. These deficiencies are barriers to many forms of effective entrepreneurship. However, all this is to the good, for under the circumstances development of appropriate institutions and development of effective entrepreneurship can be mutually supporting. What is bad is that the propitiousness of the circumstances is not readily apparent to these who are responsible for adaptation to the Green Revolution. This is so for several reasons, among which is the fact that imported top-down planning has an aura of expertise that insulates national leaders from the responsibility to mobilize internal entrepreneurial resources.

There are several advantages to utilizing the agri-business centers within rural environments as training centers for entrepreneurship. First, the responsibility of developing countries to mobilize their internal entrepreneurial resources will be assumed, and under circumstances that encourage from the bottom-up democratic processes. Second, in view of the uncertainty about just what politics and practices will lead to optimum adaptation to improved agricultural processes, small-scale alternative solutions can be tested at local levels. This minimizes risk of failure on a national scale, and it is conducive to imaginative, creative solutions to problems that are unique to specific areas. This latter advantage is especially significant in countries where there are various ethnic and religious barriers among the peasant producers. Third, the centers will provide sufficient economic opportunities to attract talented, educated, urbanized young people who can most easily be trained for entrepreneurship. This will discourage the squandering of this valuable manpower, which is so often the case. It will also discourage the elitism which tends to accrue to well-educated members of urban societies and which has inhibited the development of effective entrepreneurship. Fourth, and most important, the widely decentralized feature of the agri-business centers within numerous rural areas will encourage wide-ranging experimentation and adaptation *Pragmatic business skills in large numbers of relatively small enterprises will be developed.* The impact of such skills upon the-underdeveloped countries may prove as great as the impact of the Green Revolution itself.

The matter comes to this: attempts to build some segments of what is needed for adjustment to the Green Revolution, from the bottom up, will mobilize critical resources, emphasize democratic processes, minimize risk of failure, and sustain progress. These attempts, in essence, will utilize the strains and tensions that have been generated by the Green Revolution as abrasives to fashion appropriate receptacles for it.

(These remarks were included in the hearing record at the request of Mr. Fraser.)

STATEMENT OF WILLIAM R. PEARCE, VICE PRESIDENT, CARGILL, INC.

Arthur K. Watson recently spoke of the troublesome old tradition that requires speakers to come up with a title long before they know what they want to talk about. The tradition troubles me too, but for a different reason. My problem is that an "appraisal of grain production and demand" is so discouraging for those of us who tend to judge the world grains situation in terms of U.S. export prospects

World food grain production is increasing much more rapidly than effective demand. Because new production is fairly well distributed, levels of trade have declined in three successive years. U.S. wheat exports dropped nearly 30 per cent last year The world wheat surplus also has spilled over into feed grain markets, especially in Western Europe. As a result world feed grain exports have leveled off and the U S share has declined

While there may be some improvement this year, it's not likely to be very significant. Factors that have pushed production well ahead of demand—and these include new technology, new producer incentives and new determination on the part of governments to protect producers from foreign competition—will continue to have their effect.

Nowhere have these factors produced more dramatic results than in Asia. It is not exaggeration to say that recent increases in productivity have altered the social and economic outlook of this area beyond measure. New production of wheat and rice in Asia is certain to influence both patterns and magnitude of world grain trade in the years ahead. What seems less certain is whether the impact of this success will be felt mainly on the supply side or mainly on the demand side of the world-market equation.

There are several reasons why wheat and rice production in South and Southeast Asia has risen faster than in any other area in the last three years A change in the focus of the U.S. aid program from food aid to agricultural development is partly responsible. A sharp increase in the amount of technical assistance, grants and credits for these activities also contributed. But the most important factor has been the spread of new, high-yielding, fertilizer-responsive dwarf varieties of wheat and rice. These new seeds, combined with a package of improved inputs and cultural practices, have increased yields under field conditions by multiples of two and three. Because they mature faster and are day-length insensitive, many farmers can now achieve these results with two crops, where previously only one could be grown As Dr. Norman Borlaug, who, more than anyone else, is responsible for development of the new seeds, has observed, these "spectacular increases in yields, destroy, in one stroke, the built-in conservatism or resistance to change that has been passed on from father to son for many generations in a system of traditional agriculture." (1)

The greatest impact of the new varieties has been felt in India, Pakistan and the Philippines. India has boosted its wheat production in four years by more than half Pakistan has done at least as well. New production of both wheat and rice in West Pakistan have been more than sufficient to offset deficits in East Pakistan. The Philippines, long an importer of rice, is now producing exportable surpluses Beyond this, the new technology is in various stages of development in nearly a dozen other countries in Asia and Africa.

The full implications of this so-called "green revolution" are not easy to assess. Here even experts disagree, and they disagree to a surprising extent.

FAO, in the provisional draft of its "Indicative World Plan for Agricultural Development" under discussion this week in Rome, apparently concludes that a much more rapid increase in cereal production in developing nations is necessary not just to assure an adequate supply of staple foods but also, to increase their foreign exchange earnings. (2) Dr. Borlaug, on the other hand, is concerned that the momentum already achieved raises the possibility that a number of developing countries in the Near East and the Middle East will be producing sizable export surpluses within 5 years. (3)

Dr. Borlaug points out that Pakistan already is faced with serious challenges. Pakistan is capable of producing 10 million tons of wheat—or 2½ million tons

more than her domestic needs—on land now planted to wheat. In the absence of other acceptable substitute winter crops, Pakistan must try to restrict production—as Mexico has—or begin looking for export outlets in a world market already depressed by large carryover stocks

FAO recommendations apparently are based on the assumption that, in the long term, comparative advantage lies with developing countries and, for this reason, a shift of resources from agriculture in the rest of the world would benefit both sectors. However, as Quentin West observes in the November 10 issue of *Foreign Agriculture*, "the study itself provides no analytical proof that this is so. There is no general agreement among economists on this point . . ." (4) Dr. Borlaug has noted that comparative advantage involves not just the efficiency of the production systems. For developing countries, inadequate purchasing. storage, transport, milling and port facilities all represent serious bottlenecks.

Ester Boserup, writing in *Ceres*, an FAO publication, has suggested that, questions of comparative advantage aside, developed countries simply must accept and accommodate this new surplus production in commercial markets. This is possible, I suppose, but I think it tends to ignore recent world market experience. Failure of the major wheat exporting countries to discipline themselves sufficiently to achieve minimum price goals of the International Grains Arrangement *for their own benefit*, makes me skeptical that they can be persuaded to do so for the benefit of new surplus producers.

Nor does there seem much likelihood that world market growth will provide an outlet for the new production. Developed countries have increased their cereal production by 120 million metric tons, or 17 per cent per capita, since 1960-64.(5) OECD predicts that if present policies are retained, by 1985 they will have increased production of exportable surpluses six-fold. Only Japan is expected to increase her imports significantly.(6)

The prospect that developing countries will turn to world export markets, stems partly from the fact that income benefits of their new production have not been widely distributed. Fewer than 10 per cent of the 700 million persons dependent on agriculture for their living in Southeast Asia have been benefited.(7) As Clifton Wharton has noted, the new technology has been largely confined to regions "already more advanced, literate, responsive and progressive and which have better soil, better water management, closer access to roads and markets—in sum, the wealthier. more modern farmers."(8) The result has been that extensive investments in the new technology have added very little to employment, income and domestic markets for the new production.

This concentration of the new technology has created more serious problems of another sort. They have been described by Richard Critchfield, writing in the *New Republic*.(9)

"Since the initial impact is to make the rich farmers richer and the poor and the landless poorer, the social and political changes of the wheat and rice revolution have already been far-reaching. Last January, class war struck Tanjore, in South India's rice bowl, which had done exceptionally well in rice yield. With more to share, landless tenants began fighting landlord's for higher wages. . . . Some FAO economists believe the new seeds figured significantly in the fall of Pakistani president Ayub Khan. . . . I heard serious talk from both Indians and Pakistanis at FAO of the possibility that Pakistan's growing prosperity might lead to a breakoff of East Pakistan and its formation with India's west Bengal of a new, independent leftist and possibly ungovernable republic."

Rising frustrations of farmers who have been left behind has added impetus to migration from rural areas to urban slums. In recent testimony before a Senate committee, Dr. Philip M. Hauser. Director of the University of Chicago's Population Research Center described implications of this movement.(10)

"Poverty, hunger. frustration and alienation are serious enough in widely dispersed populations in the rural countryside. but they become an explosive powderkeg in mass populations concentrated in densely inhabited urban centers . . . In consequence, the prospect is that in the next 30 years . . . world social unrest is likely to increase not decrease . . . the government of the United States. as well as other governments. will be faced with more, not less, crucial international problems, diplomatic and military."

While these so-called "second generation" problems are now gaining wider attention they are not likely to be solved very soon, or very easily. Extending

the benefits of modern farm technology to subsistence farmers in isolated rural villages is not simply a matter of suppyling them with technical inputs—seeds, chemicals and water—and teaching them how to use them. It also will require creating the infrastructure of a modern marketing system—transportation and facilities for preserving, grading, handling, storing and processing of production. Further, it will require credit facilities and markets to channel inputs, transmit price incentives and dispose of production. None of these exist in Asia's rural hinterlands, except in very rudimentary form.

Beyond these requirements lie another set of barriers we understand very little. As Gunnar Myrdahl has pointed out in his lengthy and scholarly work, *Asian Drama, an Inquiry into the Poverty of Nations*, much of the isolation of rural areas stems from more intractible problems rooted in land tenure relationships, religious beliefs and the institutions and attitudes which spring from traditional patterns of village life. All of these influences stand as barriers to infusion of modern technology.

The solution to both these problems—new surpluses and rising tensions—would seem to lie in achieving a better balance between food production on the one hand and consumer income and demand on the other. This may require a rather fundamental change in policies supporting development.

It suggests first renewed emphasis on development of light industries to capitalize on labor-cost advantages of developing nations. As David Bell observed recently, "If increased agricultural output is to be sold, internal markets must grow, based on rising urban and industrial incomes." (11)

Recent successes in agriculture have tended to obscure the fact that, in developing countries as a group, since 1960 production in the industrial sector has grown more than twice as fast as farm production. (12) The contributions of industry to growth and development have been limited not so much by lack of comparative advantage as by tariffs and other devices which discriminate against low-cost manufactured products in developed-country markets.

President Nixon recently reaffirmed U.S. support for tariff preferences for developing countries, but there is little evidence of similar interest support in the Congress. In part this results from ineffectiveness of provisions of the Trade Act of 1962 intended to assist industries damaged by tariff reductions. So far not a penny of assistance has been paid out under those provisions. David Rockefeller has suggested creation of a National Adjustment Board with broad, flexible authority to provide prompt relief and underwrite necessary adjustments in industries and communities adversely affected by imports. (13) If this proposal is acted on, it may be possible to attract support in Congress needed to provide a growing market for manufactured exports of developing countries.

However even if we and others provide the basis for more rapid industrial growth, there is little likelihood that industry in most developing countries can absorb and provide sufficient income to people now underemployed in rural areas. Instead, as Gunnar Myrdahl and others have observed, while industrial growth gathers momentum, agriculture must serve as the welfare base for rapidly expanding rural population.

This strongly suggests a new strategy for agricultural development, guided by two imperatives. First, by the continuing need to increase production and second by what may be the more urgent need to deal more effectively with problems arising as a result of vast unemployment and underemployment in rural areas.

This does not imply that investments in the technology of the "green revolution" be discontinued. It suggests, instead, that parallel efforts be made to improve the performance of subsistence agriculture so that it can provide better employment and income opportunities for rural poor and thus shield more developed sectors from great influxes of people. William C. Thiesenhusen, writing of similar problems in Latin America, calls such a policy "contrived dualism" (14)

David Rockefeller recently alluded to the danger in confusing concepts of "growth" and "development." Both are essential. (15) Growth refers to economic progress. It appeals to developers, partly I suspect because it is easy to measure. Development, on the other hand, involves "a host of social, cultural, political and psychological factors" more closely identified with human need.

This distinction seems especially important in shaping goals for agriculture. Success of the "green revolution" has relieved immediate concern about adequacy of world food supplies. This success makes it possible to shift the focus of investment strategy in many developing countries from production and supply,

which support growth, to income and demand, which are more essential to human progress.

Our support for this reexamination of goals and strategies is bound to be misunderstood because of the interest all of us share in preserving and expanding markets for U.S. grains. Still, in this case self-interest is strongly supported and reinforced by compelling human need. If present policies for development remain unchanged the main impact of the new technology in Asia will likely be felt in world markets already depressed by surpluses If it can be redirected, it could instead provide impetus for much broader and more significant progress.

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2. *Provisional Indicative World Plan for Agricultural Development*, Volume III, FAO, August 1969.
3. See note 1 above.
4. "FAO To Act on World Plan for Agriculture", Quentin M. West and Anthony S. Rojko, *Foreign Agriculture*, November 10, 1969.
5. "Food Supplies and Economic Growth in Developing Countries—the 1970's", Lyle P. Schertz, presented at the annual meeting of the Western Agricultural Economic Association, Corvallis, Oregon, July 22, 1969.
6. *Agricultural Projections for 1975 and 1985*, OECD. Paris, 1968.
7. "The Columbo Plan—For Two Decades the Main Forces in Asian Rural Progress", John D. Parker, Jr., *Foreign Agriculture*, USDA, October 20, 1969.
8. "The Green Revolution: Cornucopia or Pandora's Box?", Clifton R. Wharton *Foreign Affairs*, April 1969.
9. "Feeding the Hungry", Richard Critchfield, *New Republic*, October 25, 1969
10. Transcript, hearing before the Committee on Government Operations, the United States Senate, 91st Congress, First Session, on S. 2701, September 15, 1969.
11. "Hope for the Hungry: Fulfillment or Frustration?", David E. Bell, Lowell S. Hardin, and F. F. Hill, *Overcoming World Hunger*, the American Assembly, edited by Clifford M. Hardin, 1969.
12. "Economic Indicators for Developing and Industrialized Countries—Regional Summary", Table 2, *Annual Report 1969*, World Bank and International Development Association, 1969.
13. "Wanted: A National Trade Policy", address by David Rockefeller to the World Affairs Council, Atlanta, Georgia, October 3, 1969.
14. "Population Growth and Agricultural Employment in Latin America, with Some U S. Comparisons", William C. Thiesenhusen, *American Journal of Farm Economics*, November, 1969.
15. "Lessons of the 60's: Challenges of the 70's", address by David Rockefeller to the International Industrial Conference, San Francisco, California, September 15, 1969.


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STATEMENT OF M. EDWARD PETERS, KERR-MCGEE CHEMICAL CORP., FOSTORIA, OHIO

Mr. Chairman: First, let me extend my appreciation to Congressman Robert Taft, Jr. for his invitation to attend this symposium.

To be in agreement with our learned panelists and in particular Mr. Dennison, I feel that Agribusiness must play a far greater role in the "Green Revolution" in the future. As I appear to hold the distinction of being the only person in attendance representing Agribusiness, let me say I am proud that Kerr-McGee Chemical Corp. does have the foresight to recognize our developing nations as potential markets in the next decade We are watching this progress with much interest and enthusiasm.

With dynamic leadership, concentrated cooperation between Institutions, Government Agencies and private Industry, we firmly believe that unparalleled goals will be achieved in International Agriculture Development in the seventies.

STATEMENT OF K. SAHDEV, SECOND SECRETARY (ECONOMIC), EMBASSY OF INDIA, WASHINGTON, D.C.

The Foreign Affairs Committee, and Congressman Clement J. Zablocki in particular, need to be congratulated on organizing a timely symposium on an extremely important and relevant topic. Not only does the Green Revolution promise to put an end to a past of hunger and improvement, but it also seems likely to determine the shape of the future, not merely in agriculture but in almost every aspect of the lives of many nations. In the international sphere it could well redraw trading patterns and lead to a recasting of the relationship between the rich and the poor nations of the world.

Such being the importance of this phenomenon referred to as the "Green Revolution", the discussions of this impressive assemblage of widely acknowledged experts cannot but be of great interest to those concerned with and involved in the changes being wrought by the new agricultural technology

One thing on which all speakers were agreed was that what had been achieved so far was merely a beginning. The real promise lies ahead, at the end of a road lined with efforts of unprecedented magnitude. This is well recognized in India whose leaders have firmly discouraged any euphoric talk of a Green Revolution resulting in a quick and easy solution to all food problems. The emphasis is on long term and comprehensive measures to increase food production at a rate fast enough to keep pace not only with the rise in population but also with the increasing per capita consumption of food which is expected to result from rising incomes. There are no illusions that this will be easy. It requires, as was clearly seen by the participants in the Symposium, dedicated effort and billions of dollars worth of investment in programmes to produce more fertilizers and pesticides, build millions of tons of storage facilities, hundreds of thousands of miles of roads to carry the inputs and the produce and a massive effort to provide more irrigation to free agriculture of the vagaries of the weather. The Government continues to accord a very high priority to meeting the resource needs of the agro-industrial sector.

Mr. Lester Brown made a very significant observation that there is always a tendency to give credit for such a revolution to the last essential ingredients to make its appearance. It is not always remembered that the miracle seeds, or even changes in policies regarding agricultural prices, could not have by themselves brought about, and cannot in future sustain, the Green Revolution. The industrial base built up in India through the efforts of the past twenty years will play a crucial role in carrying forward the momentum now being built up The Green Revolution will make heavy demands on industry and will call for substantial additional investment in it Furthermore, the rising incomes in the rural sector will lead to an expanding market for consumer goods. The Green Revolution can well trigger off a revolution in the demand for industrial products.

The Symposium stressed the possibility of large scale social disruption if the fruits of the Green Revolution are not spread more evenly. The Indian Government is well aware of these dangers It is a historic fact that technological changes necessitate social change. India's Home Minister recently told a meeting of the Chief Ministers of all the Indian States that "unless the Green Revolution is based on social justice, I am afraid it may not long remain green!" Institutional changes will, of course, be needed, to ensure greater security of land tenure, expansion of credit facilities in rural areas, streamlining of marketing arrangements and much else besides. All this will make it possible for the small farmer to benefit from the Green Revolution. As Mr. John Lewis pointed out, the new technology is not inherently biased against small farms. There is no reason, therefore, why the small farmer cannot be the pillar, instead of a victim, of this Revolution.

K. SAHDEV,
*Embassy of India, Washington, D C.*

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STATEMENT OF EDGAR A. SCHULER, PROFESSOR, EDUCATION AND SOCIOLOGY SOCIAL SCIENCE TEACHING INSTITUTE, MICHIGAN STATE UNIVERSITY, LANSING

Chairman Clement J. Zablocki and the others responsible for planning and carrying out a successful symposium/hearing on the "Green Revolution," deserve warm congratulations not only from grateful observers but from the inte-

national public interested in recent significant developments in this very rapidly changing situation. Chairman Zablocki's invitation for observers to send him, for publication, their reactions to the stimulating and informative presentation is generous, much appreciated, and deserves our considered responses. I consider the two questions posed by Mr. Zablocki perhaps the most important of those raised in the course of the session: How can we cooperate more effectively? Do you see any possibility of cooperating with mainland China in helping it solve its food problem? The following personal statement, which I am happy to submit, I trust has some relevance to the first question.

Regarding Mr. Zablocki's second question I must say I was greatly heartened to hear it raised, for it demonstrates an outlook of sympathetic, humane concern, and an inquiring frame of mind, which taken together are most likely to lead to peaceful co-existence and eventual cooperation with the People's Republic of China. Since I have lived and worked for four years on mainland Asia, never far from the borders of China, I am frequently reminded that we Americans are often unconsciously patronizing and very unrealistic in what we think, how we feel, and what we say we want to do about Asia and Asians. Today's local paper contains a story by Jon Nordheimer about a spectacularly successful young Texas businessman, H. Ross Perot, whose recent public service activities include a national ad campaign supporting President Nixon's policy in Vietnam. His point of view, I think widely shared, really the antithesis of Chairman Zablocki's is contained in the following words: ". . . all the presidents and their secretaries of state since Truman have come to the same conclusion, that we must stabilize Asia."[1]

What we fail to realize is that Asia is not ours to stabilize. Congressman Zablocki's question reveals an outlook which would permit and encourage renewal of our once warm cooperation with the Chinese, for the relationship would not cost them their self-respect. This is essential, and the sooner we learn it, and implement this understanding, the sooner we will relinquish our increasingly hazardous and potentially suicidal dependence on force and violence to assure the security all peoples seek.

Wendell Willkie clearly saw and reported the kind of international interdependence which he expected to emerge in the post-World War II period in his unforgettable 1943 book, "One World." But most people in both developed and developing countries still do not see the imperative action implications of these international interdependencies. If the insight and perspective gained by astronaut Frank Borman (quoted below) in his Apollo 8 trip to the moon is widely disseminated and generally adopted it could prove to be the most valuable return from our entire decade of American investment in outer space science and technology. Dr. Robert Leestma quotes from an article in LIFE magazine as follows: "Borman said as he caught his first view of the earth on the return flight:

" "The view of the earth from the moon fascinated me—a small disk, 240,000 miles away. It was hard to think that that little thing held so many problems, so many frustrations. Raging nationalistic interests, famines, wars, pestilence don't show from that distance. I'm convinced that some wayward stranger in a spacecraft, coming from some other part of the heavens, could look at earth and never know that it was inhabited at all. But the same wayward stranger would certainly know instinctively [this I might question] that if the earth were inhabited, then the destinies of all who lived on it must inevitably be interwoven and joined. We are one hunk of ground, water, air, clouds, floating around in space. From out there it really is one world.' "[2]

Most people in developed countries now seem to have come to accept the assumptions, outlook, and broad implications of a scientific point of view regarding our world and the solar universe. The miracle of men actually landing on the moon and returning to earth according to precise plan, all with safety, has convinced the most skeptical that, given time and resources, men using the methods of science and technology can solve problems of a complexity hitherto considered insoluble. But I was struck by the apparent assumption, which seemed to me unrealistic, of some symposium participants that implementation of the Green Revolution would be comparatively simple, now that the really difficult work of plant breeding had been accomplished, and should take far less time than the

[1] The State Journal (Lansing, Mich.), Sun., Dec. 14, 1969, p. C–7.
[2] Hearings before a subcommittee of the Committee on Appropriations, House of Representatives, 91st Congress, first sess., pt. 5, Office of Education (Washington: U.S.G.P.O., 1969), p. 1002.

painstaking and long-drawn-out process of genetic manipulation. I do not wish to minimize in any way these "miraculous" achievements to date But I am interested primarily in the people who ultimately must be willing and able to put to good use the new knowledge and technology if the world's hunger and nutrition problems are to be solved. Hence I think the thrust of Secretary Clifford Hardin's keynote address deserves emphasis: even in this rich country, where uncontrolled increases in agricultural productivity remain an unsolved domestic problem, domestic problems of hunger and nutrition also face us. Despite the dramatically encouraging evidence of the last few years, so long as agriculture remains largely subject to the weather even the Green Revolution promises no dependable solution to the food problem so far as mankind as a whole is concerned.

What we think ought to take place next, in our continuing efforts to solve these basic problems of survival, will depend very largely on our conception of how things hang together, on our understanding of the crucial variables and their control.

Dr. Harrar's paper states, and none would disagree, that the "cooperative arrangement between the Government of Mexico and The Rockefeller Foundation" which began in 1943 has played a germinal role in developing the concept of international agricultural research institutes. The International Rice Research Institute (IRRI) at Los Baños, in the Philippines, was certainly built mainly on that model. These two agencies, which have been functioning now for some years, and the two tropical agriculture research institutes now being developed in Colombia and Nigeria are largely focused on natural science and its applications. They have enabled us to go far toward solving the developing world's food problems. But having evolved the means to cope with these problems at one level we now emerge into a new phase where the riddles are of even greater complexity and more baffling multiplicity. For at the new stage, in this endlessly emerging sequence of new problems in development, we must deal, not with tractible domesticated plants, but with adult human beings who have pride and sensitivity, who insist on very considerable autonomy, who have a strong sense of the traditional, and whose material resources are so painfully limited that only the irresponsible would gamble on the vaunted new methods at the risk of falling below minimum levels of security.

Former Secretary of Agriculture Freeman stressed the solutions achieved at the technological level. But he frankly admitted the emergent problem: "How do you get people to eat new and improved foods?" He might have added, "But that just don't taste right!"

Lowell Hardin pointed out that indigenous leadership has played a major role in the Green Revolution, with governments playing supporting roles. (The contributions of private foundations are too well known and appreciated to need emphasis here.) He said the unsung hero of the Green Revolution might well be the farmer, the villager, who has rather consistently adopted "improved methods" when it was in his interest to do so.

The Rockefeller Foundation Vice President, Dr. Myers, speaking in Dr. Harrar's absence, emphasized the importance of "country" rather than international programs (though they would require strong international components): research and experimentation planned and executed within the framework, and geared to the distinctive needs, of the developing countries themselves—for they are or aspire to be sovereign nations regardless of how limited their own resources. Most critical, Dr. Myers said, are the human resources.

I think the validity and importance of these observations cannot be overemphasized. They are illustrated by the experience and achievements of the only overseas development institution I know something about: The Pakistan Academy for Rural Development, at Comilla, East Pakistan. Under the leadership of its first Director, Dr. Akhter Hameed Khan, who recently retired from government service, it has invented/discovered an impressive new model for peaceful and continuous social change which, in the long run, may well prove revolutionary. Some major components are over a century old and widely known, such as Germany's Raiffeisen type cooperative, and this country's land-grant type people's college and university. Others are so new as to be in advance, practically speaking, of the most developed countries. When Senator Fred R. Harris proposes, as he did in S. 836 in 1967, legislation to create a National Foundation for Social Sciences, I think he can find one version of his vision anticipated by a decade and now a vigorously functioning reality—on the other side of the globe. The Comilla Academy operating in its unique human laboratory illustrates some aspects of such an agency, including its inherent difficulties as well as its utili-

ties. Efficient use of scarce professional and technical manpower multiplies its effectiveness. It is creating an entire new generation of tested; increasingly competent and politically ambitious, tireless young leadership. This transformation is taking place among rural people as well as government officers. Hence the Comilla model, as a development institution which may be visited, observed, criticized, and studied for possible adaptation anywhere in the world, I believe goes far beyond those identified by Dr. Harrar as most significant.

In its laboratory area new development ideas, policies, practices, and programs are being experimentally undertaken, and scientifically observed and analyzed, on a small scale. The innovation's advantages as well as its hazards, consequently, can be experienced, discussed, recorded and communicated for the consideration and policy-making guidance of all concerned. "There is no magician technology unless it is applied," is the way Secretary Hardin put it. Since Cornell University Press is about to publish the first book in English on the subject—Rural Development in Action: The Comprehensive Experiment at Comilla, East Pakistan, by Arthur F. Raper, et al.—those who are interested can soon inform themselves if they wish.

On the symposium topic an Academy publication I received just one year ago deserves mention because it is so relevant and informative: "Cultivation of IR–8 and Irrigation Prospects and Problems: A Report on the Farmers Seminar Held From March to May 1969," by A. M. Akhanda and M. Ameerul Huq. It reports candidly on the causes of failure as well as on the generally very great successes experienced by nearly 2,000 farmers and government officers from all parts of East Pakistan when they tried out the new IRRI rice seed supported by irrigation. The reports of their discussions demonstrate that improved genetic rice strains are by no means the end of the better food supply story. For is it certain that IR–8 rice is best under all conditions in East Pakistan, for the authors state that as they were writing this monograph "more than 2,000 IRRI selections" were being tested. (P. 13)

Clifton R. Wharton, Jr., the new president of Michigan State University, has warned that even though the fear of starvation may be ended by the Green Revolution it will assure a more palatable, so to speak, but nevertheless difficult and novel set of problems. Unless those who are interested see and sequentially prepare for the entire range of major problems which emerge as we pass from one phase of increasing development to the next, from the near future to the long run, we are likely to experience needless shock, frustration, and disappointment. Furthermore, unless the benefits resulting from successful development are distributed reasonably equitably it is possible, perhaps even probable, that death and destruction will accompany the process rather than life and development.

Lester R. Brown's paper cites a New York Times account of 42 persons being burned to death, late in December 1968, "in Tanjore, one of India's model agricultural development districts."[1] He says this was because there was disagreement, "a tragic clash between two groups of landless laborers," who fought over "how best to get a share of the benefits from the new seeds being planted by landowners in the district." (P. 21) Wharton's account of the same conflict calls it a clash "between the landlords and their landless workers who felt that they were not receiving their proper share of the increased prosperity brought by the Green Revolution."[2]

Under the conditions which prevail in much of the developing world no Communist conspiracy is required to account for such violence and killing. No man today is happy to perceive himself as the means for another's enrichment under terms and conditions he considers unfair to himself and his loved one's.

The perceptive final paragraph of Dr. Wharton's paper, quoted above, deserves our most serious thought and implementation:

"The quiet, passive peasant is already aware of the modern world—far more than we realize—and he is impatient to gain his share. The "Green Revolution" offers him the dramatic possibility of achieving his goal through peaceful means. It has burst with such suddenness that it has caught many unawares. Now is the time to place it in its long-range perspective and to engage in contingency planning so that we may respond flexibly and quickly as the Revolution proceeds. Perhaps in this way we can ensure that what we are providing becomes a cornucopia, not a Pandora's box."[3]

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[1] December 28, 1968, p. 3.
[2] "Foreign Affairs" (April 1969), p. 468.
[3] *Ibid.*, p. 476.

STATEMENT OF THE AGENCY FOR INTERNATIONAL DEVELOPMENT (SUBMITTED BY MR. MATTHEW J. HARVEY, DIRECTOR, CONGRESSIONAL LIAISON)

DECEMBER 19, 1969.

Hon CLEMENT J. ZABLOCKI,
*House of Representatives,*
*Washington, D.C.*

DEAR CONGRESSMAN ZABLOCKI: In response to your invitation to send additional comments to you for inclusion in the Committee's Report on the Hearing on the Green Revolution, I am submitting two documents prepared recently by the Office of Technical Services, East Asia Bureau, A.I.D. These are examples of one approach which we have taken to give our field missions the thinking of social scientists about the impact of the high yielding varieties on the development processes in countries where we are working. The papers are being used with other ideas in shaping our programs in rural development. They indicate a partial answer to your question about what changes are being made in A.I.D.'s programs as a result of the "Green Revolution".

Sincerely yours,

MATTHEW J. HARVEY,
*Director, Congressional Liaison.*

Enclosures: (2).

From: AID/Washington.

Subject: Policy Implications for USAIDS in East Asia of Recent Experience with New High-Yielding Grain Varieties—Interpretive Summary Review SEADAG's Rural Development and Asia Society's Second International Seminars).

1. Two SEADAG Seminars held during June 1969 brought out lessons of recent experiences with the new high-yielding grain varieties and other developmental programs which have offered important policy lessons in agriculture and have pointed out significant social, political, and economic implications for governments and A. I. D.'s of the East Asia region to consider in developmental programs.

2. The continued progress of agriculture in these countries will depend on the abilities of the governments to shape agricultural policies and developmental programs to fit the needs indicated by this recent experience as brought out in these discussions and in AID's Spring Crop Review (Ref A, B, C).

3. The breakthrough with the new grain varieties and the knowledge from this experience as set forth in the subject discussions will have a direct bearing on AID's policy and program of assistance to agriculture in the countries of East Asia. Missions need to recognize the implications and to exercise leadership and guidance roles for governments where possible. Where appropriate, reappraisal of agricultural assistance programs in the light of this recent experience will be in order.

4. The first of the two SEADAG sessions was the Rural Development Seminar in Honolulu, June 19–21, 1969 on *Implications of Technical Change on Grain Production and Trade in Southeast Asia,* and chaired by Dr. Vernon Ruttan, Head of the Department of Agricultural Economics, University of Minnesota. Several outstanding economist and other social scientists from Asia and the U.S. presented papers and participated in the discussion (see Appendix 1 to Attachment A).

5. The second of the SEADAG Sessions was the Second International Conference in New York June 23–25 on *Agricultural Innovation in Southeast Asia: The Implications for Development.* This meeting was organized and conducted by the Asia Society under SEADAG auspices. Some of the scientists who had participated in the Honolulu conference also participated in this seminar Others, also with international reputations, participated (see Appendix 2 to Attachment A).

6. Participation of the Asian scholars provided a unique opportunity to gain the Asian viewpoint and to exchange views with Western scholars. Collectively, the participants offered A.I.D. the opinions and thinking of some of the world's leading academicians and scholars on developmental issues arising from the experience with the new high-yielding grain varieties. Having followed AID's Spring Crop Review, the discussions reflected knowledge gained

from this exercise in addition to providing a wider overview of economic, social, and political factors, particularly as relate to Southeast Asia.

7. An interpretive summary review of the predominating views expressed on principal issues is presented in attachment A. This review aims at relating the political, social, and economic implications expressed in the Seminars to countries of the East Asia region, and to policies and programs of USAID. Summaries of papers as presented will be forwarded to Missions, followed by final edited papers as soon as they are available. SEADAG Seminars can be of value in developing A.I.D. assistance programs when properly interpreted. Attachment A is an attempt at such an interpretation.

ATTACHMENT A

INTERPRETATIONS AND SUMMARY REVIEW OF SEADAG'S RURAL DEVELOPMENT SEMINAR AND THE ASIA SOCIETY'S SECOND INTERNATIONAL SEMINAR IN JUNE 1969

SEADAG Rural Development Seminar on "Implications of Technical Change on Grain Production and Trade in Southeast Asia, June 19–21, 1969—Honolulu, Hawaii, Chaired by Vernon Ruttan (Dr.).

Asia Society's Second International Conference on "Agricultural Innovation in Southeast Asia: The Implications for Development," June 23–25, 1969, New York, N.Y. (Chaired by Ambassador Kenneth Young).

1. GENERAL STATEMENT

*SEADAG Seminars Highlight Economic, Social, and Political Implications of Green Revolution*

Two outstanding SEADAG seminars were held during June 1969 to review influences and implications of the introduction and spread of the new high-yielding grain varieties in developing countries, particularly in Southeast Asia. The first one was the Southeast Asia Rural Development Seminar held in Honolulu June 19–21, 1969, on the subject, *Implications of Technical Change on Grain Production and Trade in Southeast Asia: The Implications for Development.* The meetings brought together some leading American and Asian scientists and scholars well known in their professions and experts on the Asia situation (see Appendixes 1 and 2 to Attachment A).

The following review by East Asia, Office of Technical Services, AID summarizes predominating views expressed in the sessions on principal issues facing the countries of East Asia Region in agricultural development, and on implications to USAID's policies and programs These represent also a confirmation and further extension of AID's Spring Review assessments.

2. GOVERNMENT POLICY AND AGRICULTURAL DEVELOPMENT

*Technological, Economic, and Social Implications of Breakthroughs with New Grain Varieties Necessitate Careful Assessment and Development of New Government Policies for Continued Agricultural Progress*

Governments of LDC's need to re-evaluate their development policies in the light of the recent experience with the high-yielding grain varieties. Appropriate policies, pursued vigorously and with dedication can do much to overcome traditional inhibitions that have blocked progress of agricultural programs for years.

USAID efforts should aim at strengthening LDC policy actions In this respect, significant influence by U.S.A.I.D. Missions on the formulation of appropriate government agricultural and development policy through one or two specialists may contribute more to agricultural development than a dozen technicians working at operating levels on scattered projects. Such important influence can be directed at any one or more of the factors described in this review.

There is need to reorient thinking and programming in agricultural assistance away from A.I.D.'s traditional approach of broad extension development for transfer of U.S. know-how. Programs and efforts should be shifted toward high level policies concerning factors that are being commonly referred to as "second generation problems", and others that sparked the breakthrough and are required to sustain it.

Among the critical "second generation" issues are: pricing, markets, credit, and trade; processing, storage and expansion of agri-business activities; improve-

ment and expansion of irrigation with attention to water management; development of additional rural infrastructure; planning of agricultural goals for a diversified industry to realize full potential of the comparative economic advantage of each country; and political and sociological consequences of the new technology.

To be considered among the factors which sparked the breakthroughs and are necessary to sustain it are: agricultural research utilizing inter-disciplinary teams for development of adaptive technology suitable to local ecologies, climates, and cultures; pricing and farmer incentives; organizing of single-crop campaigns that cut across agencies to achieve "organized cooperation"; and assurance of availability of agricultural inputs, including improved seeds, fertilizer, and water through cooperative programs of government and industry with heavy reliance on and participation of the latter.

### 3. PRICING

*Government Subsidization of Producer Prices at Incentives Levels Considered Necessary in Initial Stages for Farmer Adoption, but an Economically More Suitable Base Must be Sought as Continuous Policy for LDC's*

Those countries which have made progress with new grain varieties have followed pricing policies which were favorable to farmers. In some instances, these policies reflected changes from previous government practices of subsidizing consumer prices by enforcing low retail ceilings which depressed farm prices below production incentive levels. Such practices had been abandoned in those countries where breakthroughs were made. In such cases, prices were allowed to seek world levels, or were guaranteed at minimum levels by the government through programs of market intervention where the government bought a percentage of production at the guaranteed price. Experience has shown a definite need for government intervention in markets during peaks of harvests in some countries through purchase and storage programs to stabilize prices at minimum price levels for farmers.

Experience also signals caution against subsidization programs that generate surplus production which LDC governments cannot finance, which local processing and storage facilities cannot handle, and which markets cannot absorb. Encountered in almost all cases of successful increases in production were inadequate markets to absorb all the increases.

Pricing of inputs for new technology has also proven to be important for farmer adoptions The ratio of costs of inputs to the selling price of rice, together with increased yields have combined to increase farmers' incomes. This has been a key factor to influencing farmers to change.

Nevertheless, the high political sensitivity of inflated consumer prices is recognized, particularly with rice in Asia where governments can fall on the issue of scarcity of rice and highly inflated prices. However, the introduction of improved farming technology can serve the interest of both the farmers and urban consumers. There are a few excellent examples, such as in the Philippines, of recent experiences that illustrate these ultimate benefits Temporary subsidies through floor prices to farmers may be necessary.

USAID's are encouraged to give priority attention to pricing issues with careful selection and use of highly specialized expertise and appropriate LDC indirect involvement. A.I.D. and L D.C.'s have limited experience with this complex subject and there is normally inadequate local competence to deal with it.

### 4. RESEARCH

*New Innovations Emphasize Increased Importance of Adaptive and Basic Research to Solve Second Generation Problems and to Seek New Breakthroughs Suitable to Wider Ecological Ranges*

New technology for agricultural plants and practices has evolved from research in the ecological conditions and climate of the region, country, and subgeographical areas involved. While research results may have shown a wide geographical area of transferability, the transfers have been possible only within rather narrow ecological and climatological limits; factors such as temperature ranges, total hours of sunlight per crop, length of days, water availability and control, soils, and other factors place limitations on transfer of research results. Even within these ranges of transferability adaptive research is needed to in-

troduce the new varieties to new areas and adapt them to varying conditions of diseases and insects. In this respect, some of the new varieties have responded better than others when introduced into these new areas.

The breakthroughs with high yielding varieties resulted from research within, given ecological and climatological conditions These spectacular results with the new varieties have emphasized the importance of research in government policy. However, the genetic research which has exploited characteristics inherent in plants is not enough. Additional research is required to sustain the advances against diseases and to develop new genetic stocks suitable to the ecological conditions and climates of the areas where they are to be grown.

The rapid increases in production of grains made possible with the new varieties generated new problems. These require research in a number of physical and social sciences to realize the full potential of land and water resources, and also to overcome inhibiting economic, social and physical factors which lie between producers and consumers for achieving an optimum developed agriculture. Important among these are water and soil management, land utilization, crop multiplication and diversification, storage, transport, credit, farm organizations, agri-businesses, marketing and trade systems management and technique, research institutions and systems, trained manpower requirements and availability, infrastructural requirements, and training and educational requirements.

USAIDS are encouraged to sponsor sectoral studies for appraising research needs and priorities among these factors as a means of advising governments on policy approaches Such appraisals will enable Missions to determine the most effective use of U S resources in assistance programs.

Once research programs and goals are determined, research can be made most effective through the use of inter-disciplinary teams composed of sufficient disciplines to form a "critical mass" of research talent In determining the degree of in-country institutional development for research, internal potential and effectiveness must be weighed against assistance that can be received from regional programs and institutions. These are proving to be effective and efficient in most areas of basic and applied research.

### 5. EXTENSION

*Recent Successes with High-Yielding Varieties Indicate that Extension can be Successfully Used with Minimum Cost, Organization, and Efforts once Adaptable Technology is Available to Extend; However Technical Assistance Aimed at Development of Extension Institutions and Methodology, While Laying a Foundation, Has Not Been a Major Factor in the Achievement of Rice and Wheat Breakthroughs*

An extension service is important, but it cannot be succesful without adequate technology to extend. Experience has demonstrated inadequacies in attempting to transfer agricultural technology from developed countries to LDC's of different climates, ecological conditions, and cultures without adequate adaptive research. The sudden successes in farmer adoption of the new grain varieties and the new technology which they require have taught us that previous failures were due to the lack of adequate new technology suitable for these areas Extension programs have fallen short of desired goals because science had not given them enough to extend. Farmers had not adopted the use of fertilizer on old varieties because of the 20 to 40% increase in yields was not sufficient to warrant the risk of loss of investment, and more importantly the risk of loss of a subsistence crop. Yields of three to four times the amount of traditional agriculture have been shown to be necessary by recent experience with the new grains as incentive to bring about change.

Experience has also demonstrated that once the technology is available and prices are right, the job of extension becomes minimal in terms of an organized government service A well selected and trained, small service with adequate transportation, financial and material support for demonstrations can be effective with key farmers who act as innovators. Other farmers will follow the examples rapidly, once a worthwhile result is demonstrated. The rapidity of the spread has been swift with the new grains. The role of the private sector is important. Private enterprise through sales campaigns, credit programs (rural banks) and marketing and processes have also provided extension services which complement government efforts.

Single crop campaigns organized and planned by government, with private sector participation, giving attention to the complete package of requirements

have proven effective where there was strong motivation and dedication, adequately developed infrastructure and resources, including irrigation facilities, arable land, and available inputs. Single crop campaigns have cut across agencies in what has been termed "organized cooperation".

Major attention must be given to assuring available supply of certified seeds and fertilizers. While it has fallen on governments to establish foundation seed stocks and to provide facilities for laboratory testing of seeds, private sector participation in seed multiplication has expedited the production of an adequate supply. Likewise, the private sector has proven to be more efficient and effective in procurement, or manufacture, and distribution of fertilizers and insecticides than government programs to import and furnish these inputs, even at subsidized prices.

Unless planners of crop campaigns can foresee and assure the availability in each farming area at the farm level of needed fertilizers and other inputs at the exact time of the season needed, extension efforts will be useless

Likewise, availability of credit to purchase the inputs is essential While the recent successes have not demonstrated the role of formal credit institutions as a significant factor in all countries, the need for credit was well established. Credit from traditional sources of money lenders, individuals and families was available in most countries, and from some formal credit institutions in some. The traditional sources will increase as investment requirements expand for land and irrigation development and for use of more sophisticated technology. The improved efficiency of farming and increase in profits made possible by innovations enable agriculture to become more competitive with other investment possibilities for available credit.

### G. AGRICULTURE GOALS

*Self-Sufficiency in Food Production is a Goal which can be Realized more quickly Now, But New Considerations in Foreign Trade Relationships, Domestic Marketing, and Agricultural Diversification Opportunities Warrant Analysis by LDC's of New Targets and Goals*

The common agricultural goal of LDC's is to reach self-sufficiency in food production, focused on the main staple food crops. For most of the countries of Asia, this meant a goal to produce sufficient rice to eliminate imports and then to produce exportable surpluses It has been proven that with the new varieties and technology, reaching self-sufficiency is much easier than originally believed. In most situations, the margin of difference is small. A 5% increase is sufficient to fill the gap in many countries, considering that as little as 3% of world rice production reaches international markets, normally. A 10% increase can cause a surplus.

There is the longer range requirement of keeping pace with population increases, which usually range from 2 to 3% annually in LDC's. The Green Revolution alleviated much of previous concern about potential of LDC's to solve their food deficit problems in the short run even with such population increases. However, the new thinking is based on assumptions of the existence of capability in countries to meet basic requirements for expanding internal markets. These requirements have been defined by economists as a need to increase per capita incomes and to achieve adequate distribution of income for increasing purchasing power of the poor. Achieving these requirements will be dependent on transfer of labor from the farm to employment in the non-farm sector and on public policy.

Expansion of internal markets is necessary to sustain the rate of investments in technology by farmers which has been achieved with adoption of the high yielding grain varieties A continuous and responsive market that will provide incentive prices for farmers is necessary. Prices of farm products must stabilize at adequately high levels to provide sufficient marginal return to farmers to warrant continued rates of investment in fertilizer and other inputs. Without these market conditions of favorable prices, technology would lose its advantage. Yet, the conditions for expanding internal markets in LDCs of SEA are improving very slowly, and in some cases they are not improving at all as population grows.

Population growth in most of the SEA countries is diluting economic gains and draining resources to sustain livelihood at low standards. Employment levels in the non-farm sector are not rising at a date to keep pace with popula-

tion increases and migration from rural to urban areas. This is forcing policies of relief, overstaffing of public offices (as in Indonesia), and increases in partial employment and inefficient use of labor. These problems have added political sensitivities that are encouraging policies unfavorable to economic and agricultural development in some situations. Governments have had to use for social welfare programs such scarce resources that could be used for development of infrastructure and other programs which would contribute to economic growth.

Furthermore, as pointed out by the Chairman of the Seminar in Honolulu, there are very substantial "leakages" in the market structure of LDC's of SEA in the form of resources devoted to product markets during the labor transfer process. It takes more services to get a kilo of rice to a family in the urban area than to a family in the village. Consequently, the percent increase of rice entering market channels is larger than the percent increase of demand. Offsetting such leakage requires technical change.

In countries with static employment and income levels, consumption patterns change little. Rice and other similar staple foods have low income and price elasticities of demand. That is, people will not vary their consumption habits appreciably with moderate changes in prices of rice, or moderate changes in their incomes. Where price is very inelastic, say —0.2, income elasticity also tends to be low, say +02. As per capita income increases, people reduce rice consumption and increase consumption of available protein and other foods which have higher income elasticities of demand, as has happened in Japan. Availability is an important policy implication, because it can be influenced through government import regulations and domestic agricultural production policies. In fact, it has been shown in Japan that such policies can influence the elasticities of demand.

With the limitations imposed on agricultural development by one-crop self-sufficiency goals, governments and Missions need to examine agriculture sector strategy to see if there are economically feasible additional targets to implement along with self-sufficiency programs. In particular, the goal of self-sufficiency itself should be examined to determine the price being paid by the government in terms of financial costs and possible loss of external markets for other products, creating an imbalance in trade with other countries.

*Production Alternatives for Exploiting Comparative Advantages of Each Agricultural Area and of the Country*

Some deficit rice producing countries which aimed at exporting after reaching self-sufficiency have had to reassess their goals toward diversification of agriculture to exploit any comparative advantages of agricultural areas and of the country for internal and export trade. Several non-traditional rice exporting countries of East Asia aimed at export programs during the period of rice shortages and high prices. When they reached the stage of temporary domestic surpluses, many were disappointed at their inability to enter international trade to any signficant extent. The world supply situation had changed and prices had declined. Also, they were unable to meet the high quality standards on international markets. This may have been a lesson to some countries.

The outlook for rice trade is predicted to worsen by increased competition of wheat and increases in the supply of rice. Temporary commodity surpluses in LDC's in Asia is an experience that is likely to be repeated in the future.

Therefore (without minimizing the need for continuing production targets of basic food grains), policy measures and distinct goals, based on careful sectoral studies and analysis, are needed. Countries must plan land and water resource utilization around the greatest comparative natural and economic advantages afforded. This is true of production for domestic consumption as well as for exports.

The high-yielding varieties of rice are suitable for lands with rain-fed and artificial irrigation. However, highest yields are being obtained on lands with controlled artificial irrigation, particularly during the dry season. These lands prepared with the appropriate methods offer the advantage of 2 to 3 crops per year in Southeast Asia, and a secondary crop of vegetables in between the rice crops.

With this natural advantage, it is an economic axiom that commercial rice production will become concentrated in those areas of higher productivity. It also follows that countries possessing the best natural conditions and greatest development have a comparative advantage in rice production over other rice producing countries. The Indus Basin is said to have the greatest potential comparative advantage among Asian countries because of its high level of availability of solar energy and controlled water. Research on genetic stocks

to development varieties most suitable for the varying conditions of each area can further exploit any comparative advantages which the area may have over others.

The less productive areas for rice, particularly hill rice without rain fed irrigation facilities, will either revert or remain a base for only a subsistence crop, or will be replaced with dry-land crops more suitable for these areas, such as some of the new grain sorghums, corn, and possibly wheat, for human consumption and livestock feed. However, research is needed to bring about such improvements.

Problems of consumption habits, infrastructural development (particularly processing and storage), and markets arise with the introduction of new crops. Nevertheless, these must be considered for continued development of the agricultural economies of East Asia countries. The urgency for improving land preparation techniques in order to reduce the time between plantings in multiple cropping introduces the need for mechanization. Mechanization is also needed to speed up harvesting, threshing, and drying for this reason and because of weather. The intensification of the use of labor brought about by multiple cropping and use of fertilizer and other innovations also introduces the needs for mechanization, particularly during peak periods. to prevent waste and improve efficiency of labor as countries become faced with labor shortages due to industrialization and migration of people from rural areas for other reasons. Considerable research is underway at IRRI and within private industry on mechanization of various agricultural operations

Tree crops are important to achieve a balanced agriculture, from the standpoint of export markets, land utilization, domestic employment and dispersion of population in some countries. Fruits, tea, coconut, oil palm, rubber, and others are examples. For example, the coconut tree will grow where almost no other economic plant will. There are comparative advantages found for one or more tree crops in almost every country of East Asia. However, the possibilities of their continued successful cultivation and marketing of products will depend to a considerable degree on research to develop varieties with improved yields and to improve quality of products that will remain competitive in international markets.

For export possibilities of fruits and vegetables, fresh and processed, the markets of the metropolis of Asia are expanding and should be explored. One discussant pointed out the great potential in Japan, whose markets are benefitting a number of Asian countries, but not enough. As another example, the Republic of China has recently begun producing mushrooms and asparagus for Japan and Europe.

Protein crops and livestock become potential products of an advancing agriculture where effective demand is increasing. Effective demand results from increases in per capita income which require development of industries and business to complement agricultural development. At present. domestic demand appears to be increasing more rapidly for protein crops than for livestock. Both possibilities have broad economic implications requiring evaluative studies, and policy considerations for establishment of defined targets including new processing and storage facilities, and market promotion. Some sociologists advocate increasing protein content of diets as country and technical assistance goals. However, most economists, while recognizing the desirability of such goals, take a more pragmatic approach of aiming at economic goals with improved diets as a resultant benefit. The development of effective demand by increasing incomes and the improvement of efficiency of production in order to lower prices are considered by economists as necessary goals to improve diets and the standards of living.

Some areas of Southeast Asia have a natural relative comparative advantage for livestock production through grazing and through feeding local vegetation with some grain waste supplements. This potential is being exploited to some extent. However, the scientific application of chemicals, such as urea, to carbohydrates abundantly available in certain areas has hardly been touched. The feasibility of such development will depend on careful market analysis, especially export, appropriate government policy and legislations, development of managerial expertise, and establishment of slaughtering, meat processing, and cold storage facilities In considering a livestock industry, the animal production goal should concentrate on feeds, improvement of grasslands and development of management. Attempts to upgrade local village stock through importation of exotic breeds has proven to be a waste of time, unless the basic food problem has first been solved.

The market and feed potential for poultry and swine is growing in Asia more rapidly than for larger animals The potential for corn production and feeding of small animal and poultry should be analyzed and included among country goals for development where feasible.

*Development and Improvement of Rural Infrastructure*

Other second generation problems need attention in determining agricultural goals. The rapid surge of the "Green Revolution" has exploited infrastructure, land and related capital that had required generations, and even centuries to achieve in some countries Expansion and improvement of infrastructure will be required for significant increase in production of staple food crops in most countries in the future.

The new grain varieties have already largely utilized developed irrigated lands Further expansion of these and new crops needing irrigation will require improvement of existing facilities, development of farmer organizations for operations and management, improvement of water management, construction of new facilities to harness new resources, and development of ground water resources.

In the order of priority, the Report on The Survey of Asian Agriculture by the Asian Development Bank places improvement of antiquated gravity systems in most countries as being first; the next, development of surface water through diversion and pumping; and the third, development of new facilities for impounding water.

SEADAG discussions also underlined the need for attention to studying and overcoming social and cultural problems, for developing farm organizations to manage and control tertiary systems, and for research in water management on crops. Little research work has been done, particularly in the tropical setting on influences of timing and quantities of water for crops. In the case of rice, the research scientists present pointed out that the unknown variable in research results of between 6 metric tons and 12 metric tons per hectare under equivalent known conditions may lie in the area of water management. National goals of government for irrigation development and improvement were emphasized as being of priority importance for continued agricultural progress.

Among other important infrastructural problems that have been concommitant to or arisen as a result of the breakthroughs with grain are rural roads, transportation facilities, processing, storage, and organizations and trained personnel to operate and manage new facilities.

Further progress in agricultural development will require that all these factors receive appropriate study, planning, and resource allocation in staging agricultural development. In fact, the next major advance in agriculture following the initial successes of the cereals breakthrough only can come from attention to all these factors, and will necessarily be slow.

Attention to all the factors has been termed by some as the "package" approach. Such planning is implied in the "single crop" campaigns. Others have felt that this type of program planning can best be achieved by the "systems" approach of research, analysis, and retrieval using modern techniques and communications However, the possibilities of wide application of such technique on a national scale in less developed countries is doubted by many.

*The By-passed Areas*

Many less productive agricultural areas have been by-passed by the Green Revolution for a number of reasons. Usually they have lacked the potential because of poor soils, rough and hilly upland, making cultivation difficult, lack of water resources, and level land suitable for irrigation, and remoteness, making infrastructural development uneconomical in terms of potential. Often they are inhabited by less advanced people engaged in primitive agriculture.

The roles of such areas are questionable in a modern commercial agriculture. However, some of the areas may be important for forestry for commercial use and conservation to protect more fertile lands and irrigation facilities in lower areas. Others of the areas may be important for livestock grazing. Then, there are areas in between whose potential may be marginal for existing use but greater for new crops, such as dry-land grains for livestock. If the lands are not suitable for any such economic use and are still used for primitive subsistence farming, more appropriate use of the labor might be found in more productive areas.

The question of dealing with by-passed areas will depend on the economic potential of such areas as well as on the urgency of social considerations. This will require careful studying.

In general, it has been the practice of most foreign assistance donors, as well as recipient governments to concentrate on the most fertile areas which offer the potential of quickest and greatest return There are important exceptions where social and political factors outweigh these purely economic considerations for assistance donors; the Northeast of Thailand is one example.

### 7. A STATISTICAL BASE

*Accurate Crop Reporting and Forecasting Are Essential Adjuncts To Support Government Agricultural Policies Involving Marketing Activities, Price Support, Stabilization Programs*

Accurate crop reporting and forecasting become more important and critical as governments enter the market arena in price support and stabilization programs. Furthermore, as agriculture changes from the traditional to modern, output and yields become more difficult to estimate and predict. It may have been easier in the traditional setting through experience to determine production within a 5% range. However, with a changing agriculture, most countries lack the system and trained personnel to approximate this margin of accuracy. The science of modern crop forecasting is practically unknown in most countries.

When governments begin dealing with farm commodities, large sums of money are involved. Political considerations may impinge on objectivity. Decisions based on erroneous statistics, or on political influence can be costly to governments and disastrous to agricultural progress in a country. It is essential for sound planning and development of a rational agriculture economy that governments develop scientific systems manned by statisticians and economists and free from political influence for crop reporting and forecasting.

### 8. MANPOWER PLANNING, EDUCATION, AND TRAINING

*Manpower Planning and Specialized Education Are Essential for Agricultural Development, but Mass Education Has Not Been a Factor in Progress With Introduction and Spread of High-Yielding Varieties*

Mass education of the rural population is not considered an essential factor in the agricultural progress made with new varieties. The successful adoption of new technology with the high-yielding grain varieties demonstrated clearly that illiterate farmers respond to economic incentives as well as literate farmers, and can and will learn introduced innovation when motivated. Furthermore, their rate of learning depended more on the degree of their motivation—not on their degree of literacy. The only distinction was that the first adopters—the innovators—were the more progressive farmers of the areas who probably had some degree of literacy and primary education. This may be, in fact, the only economic justification that has emerged for educating a portion of the farm population as a means of changing primitive agriculture—a selective education to primary and elementary levels of a few farmers in each area.

On the other hand, as agriculture becomes more sophisticated and competition is sharpened through commercialization, farm management becomes more complicated. While this increases the justification for some degree of education for part of the farmers, this alone would not justify mass education of the farm population.

This argument on education does not apply to those government service men, management and technicians of private enterprises, and institutional trainers who must serve agriculture, introduce innovations, and perform training. Obviously, education becomes important here, and the degree of education needed is determined by the degree of skills and expertise required Herein, education can be selective.

In countries where successful break-throughs have been made, there was an educational base for the break-through. It was necessary to supplement the education with specialized training, as was done at IRRI in training the "change agents". For sustaining the break-through, in most countries it is found that there is a shortage of professionals and skilled technicians to carry on scientific research, to fill teaching positions, particularly in the graduate fields, and to

manage and operate new agricultural organizations and enterprises that are needed to complement the increases in production. New credit institutions, processing and storage industries, and marketing and sales organizations require professional managers and technicians with basic education and specialized training.

While it was recognized that the LDC's are in short supply of professional manpower, there is a great waste of existing manpower, both professional and nonprofessional. In the use of professional staffs this is due to lack of concentration and support for useful functioning of available professional personnel, duplication of institutions and services and lack of coordination. Back of these weaknesses are the lack of adequate personnel practices, salary incentives, and career management on the part of governments and educational and research institutions to gain the dedication and full attention of personnel to their duties. In farming, inefficient use of labor on all operations is a factor impeding multiple cropping in many areas where the new varieties have been introduced, as mentioned before.

Improvements can be made through careful manpower studies and planning, appraisal and revamping civil service practices, and analysis and coordination of institutions and services, particularly the government services and educational and research institutions. The needs for technical assistance in this area are great.

Discussion brought out the need for more attention to the development of graduate educational institutions in the physical and social sciences in Southeast Asia, particularly for Ph.D. candidates entering the field of scientific research and teaching. Too many Asians are receiving advanced scientific education in western countries and are unable to relate to the environments, culture, and ecology of their countries. This does not mean that every country should or would be capable of supporting such advanced institutions Regional approaches require greater attention in optimizing needed educational opportunities for specialized training.

### 9. TRADE AND REGIONAL COOPERATION

*Self-Sufficiency in Rice Production Brings Trade Problems for SEA. Countries and Emphasize Need for Diversification To Capitalize on any Comparative Advantages and Market Opportunities With Asian Industrial and Metropolitan Outlets*

Trade policies and problems are increasingly important factors in setting agricultural goals, and an awareness of these is necessary for advising on country agriculture strategy.

All countries of East Asia want to export and trade with each other but many of them, particularly those in Southeast Asia are relatively homogeneous. They lack sufficient complementarity necessary for much trade. The comparative advantages of each are small. Countries have most to gain if they have differences. Thus, the less developed must look to the more developed, industrialized countries of the area to find significant differences The obvious appears; Japan, Taiwan, Singapore, Hong Kong, and to some extent Thailand. The trade relationships that exist here are for industrial goods from the Eastern metropolis with agricultural commodities from the countries of Southeast Asia.

Because of these relationships, the trade theorists hold out more hope for bilateral trade arrangements than for regional cooperative efforts for improving trade.

A number of efforts have been made for regional cooperation without much significant results. National interests and passive attitudes have dominated regional interests. Notable exception have been the establishment of the Asian Development bank and the IRRI experience. However the latter was in the nature of a private supported regional program which did not involve regional cooperation in research. The ADB offers a good example of what can be achieved when regional goals are specific. Most cooperative efforts which have failed have been proposed for the sake of cooperation without specific goals. Also, most have been on a government to government basis. There is need for greater cooperation through the private sector.

Trade policies can encourage or discourage private trade cooperative efforts. The tendency of LDC's is to use protectionism for fledgling industries. Such measures will discourage sound foreign investments, institutionalize inefficien-

cies, and discourage national production patterns. The trade theorists argued that governments' fear of losses from liberalization of trade policies is exaggerated. Losses would not be great and would be replaced by economic benefits to the countries.

Some of the more industrialized Eastern countries also have protectionist trade policies which discourage trade. The view was expressed that Southeast Asian agricultural countries offering markets for industrial products for Japan and other more developed countries should seek to strike a harder bargain with these countries and to demand greater reciprocity. They should demand outlets also for some of their processed as well as unprocessed agricultural products. Agriculture of the Southeast Asian countries could progress more rapidly by processing more of their own agricultural commodities for industrial markets like Japan. This is particularly true in foods, such as fruits, vegetables, meats, and fish.

The Southeast Asian agricultural countries have much to gain by liberalizing their foreign investment policies to attract the capital, technical know-how, and managerial skills from industrial countries, particularly Japan, which have potential markets for Asian products. Joint-venture arrangements would be mutually beneficial.

Bilateral agreements also are believed to offer greater hope in dealing with surplus problems than do regional agreements. Recent proposals through the Food and Agricultural Organization (FAO) and others for a regional arrangement to deal with surplus situation in rice have not materialized. These efforts have foundered on the problems of financing surplus programs and the lack of facilities in any country to handle surplus stocks.

Concessional agreements between an LDC and developed country have proven to offer the best mechanism for dealing with deficits as well as for providing a useful mechanism for helping to finance development. Such measures have been used for grain deficits, primarily, and to a limited extent, other products. They could be used more. There are certain disadvantages. One is that they put trade on a government to government basis which interferes with private trade.

Recent rice surpluses in some countries of Southeast Asia have generated criticism from traditional and new rice exporting countries against the U.S. for its concessional agreements with some deficit countries of the area which bring in U.S. rice. Some critics have proposed regional agreements to exclude U.S. rice. This would be a futile and misdirected effort which is not focused on the economics of the question. It is true that U.S. rice through concessional agreements and private trade has accounted for as much as 65% of rice imports in the area during world shortages. But the U.S.'s share is rapidly decreasing with increases in production in deficit countries which the U.S. has been supplying. As deficit countries reach self-sufficiency the U.S. will continue to eliminate concessional arrangements in rice with those countries. However, this will not mean an end to Asia's grain marketing problems. Wheat from the U.S. Australia, and Canada will remain a competitive factor with East Asian rice.

During the world rice shortage, the price of rice was more than double that of wheat, which has been in surplus supply in the western countries. This price differential caused Communist China to import wheat and export rice. Such trade, the excellent crops in rice from favorable weather in producing countries during 1968–1969, and the new technology have alleviated the world shortage of rice, lowering its price and bringing it more into equilibrium with wheat and other grains.

The outlook for the future is for an increase in supplies of all grains, with the western countries expanding their surpluses under support programs, particularly wheat and corn. Although these countries could curtail production by changing price support policies, this is not expected to happen, except for rice in the U S. to a limited extent where there has been some overproduction specifically aimed at concessional needs. The supply of rice is also expected to continue to increase faster than effective demand. Prices of all grains are likely to decline, causing the prices of rice, wheat, and other grains to become further equalized.

Countries of East Asia can look to little prospect of improving their export position on rice. As deficit countries reach self-sufficiency, traditional markets in Asia are eliminated, and markets outside Asia shrink from competition with western production of rice and other grains. One traditional Asia market has

already been eliminated when Japan's changing food consumption habits and increased rice production changed it from a price deficit to surplus country. Japan exported 300,000 M. T of rice in 1968 and is expected to be able to reach 1.5 million metric ton surplus if its support policies are continued. Some observers feel that Asian reaction against Japanese rice exporting may cause her to change its policies. Only South Korea and Communist China offer prospects of continuing to require rice imports However, as pointed out above, the world supply situation in other grains and government policies can influence these markets.

On the supply side in Asia, Thailand and Burma are expected to remain strong. South Vietnam is expected to regain its export position. However, with smaller markets to share and with increased competition, the largest current exporter, Thailand, will probably have to reduce its rice exports, during the next few years.

The quality of rice will be an increasingly important factor in rice trade. The new exporting countries are finding it necessary to assure establishment of international standards to meet export requirements. This requires investment in improved milling equipment for new exporters. While none is known to have invested in rice par-boiling equipment, such investment possibilities might be studied. So far, the U.S. and Italy are the principal suppliers of par-boiled rice in the export market.

Par-boiled rice offers considerable quality advantages. It reduces fuel consumption for consumers and resists insects and mildew because of its dried and hardened surface which is relatively non-hydroscopic. Furthermore, par-boiling is said to reduce milling losses by as much as 7%, in addition to preserving its vitamin B content by driving it into the kernel of the rice from the skin. Par-boiled rice receives a price of about $1.50 per hundred pounds above regular milled rice of superior grade. Cereal grains other than rice hold out favorable trade prospects in East Asia.

Corn demands have been increasing steadily, principally in Japan, but also in other Asian countries Taiwan is expanding its poultry and swine production, requiring importation of greater amounts of corn. The demand for this purpose in India is also increasing. Consumption in most Asian countries will be growing for animal production. Corn production to meet the demands has been increasing at a very rapid rate in Thailand, first through bi-lateral agreements between the two countries, and more recently through private trade channels which are more favorable to the country.

Japan is making an effort to help increase corn production in Indonesia through technical assistance and investments to meet its expanding demands from Asian sources. Nevertheless. Japan must still look to the U.S. as its principal source of supply of corn, despite the disadvantage of greater distance with higher freight charges. The advantages to Japan of U.S. corn are higher quality and assured availability through grain marketing exchanges.

An important trade handicap to East Asian countries is the lack of a commodities exchange where commodities can be traded on a current and future basis. Such an exchange in Southeast Asia, when feasible, would offer tremendous encouragement to trade. Until such is established, the countries cannot fully realize their single most important comparative economic advantage over western countries for trading in Asia—their location.

Despite the relative homogeneity in agriculture of the countries of Southeast Asia, comparative advantages can be found for certain crops and products among them for trade with each other in competing with the West. They all have a climatic advantage over temperate western climates. According to views of some economists, as expressed at the Seminar, this advantage, which will permit 2 to 3 crops per year, and the lower standard of living of the Asian farmer, may tip the scales for the East in competing with the extensive techniques of single crop, temperate western countries in the cultivation of new high-yielding varieties of rice and some other grains for export trade. Not all participants shared this view.

The critical comparative advantage in rice production among the countries of Southeast Asia will go to those countries having the suitable arable land and developed irrigation facilities, which will permit the 2 to 3 crops per year, according to their abilities to adopt the improved technology to fully utilize the land to attain these crop potentials.

## 10. OTHER SOCIAL, POLITICAL, AND ECONOMIC IMPLICATIONS

*The "Green Revolution" Arouses Political Conscience of Rural People, Threatening Power Balances in Many Instances, and Raising Questions About Patterns of New Socio-Economic Relationships in the Rural Service*

Introduction of the new grain varieties have brought changes in behavior patterns and have aroused a political conscience. Mobility of rural people is increasing. Contractual relationships are developing and entrepreneurships are emerging.

Changing the peasant farmer is introducing a number of social and political implications. Expectations are increasing; felt needs are greater; and improvements in public services are being demanded of government. An aroused political conscience is causing peasant farmers to be more vocal in their demands. This awakening can lead to serious disturbances and even blood shed, as has been demonstrated in the Pakistan case. The development of a political conscience among farmers can mean the change of the political power a base from the urban to rural areas, or at least the enlargement of the latter at this stage of development. Such implications can have far-reaching effects on governments and countries of Asia. Attention must be given to political development along with economic development. Training of leadership is necessary to provide constructive direction to and organization of disenchanted rural people.

While economic progress may lead to rural disturbances and violence, the potential benefits accruing to the mass of underfed, underprivileged, and impoverished rural people of Asia from the introduction of scientific advancement outweigh the adversity of such social upheaval, according to judgement of developmental scientists at the New York Seminar. The feeling was that at least the people will be fed

A new environmental is being created, favorable for restructuring the rural economy, by the changes taking place with the introduction of high yielding cereal varieties. Farmers brought into the commercial market place and faced with new economic forces of sales organizations and made into entrepreneurs, soon see the need for cooperation with each other. It becomes evident to them that through organized effort a bargaining power can be created to deal with these new forces. Thus, the appropriate environment for cooperation paves the way for successful establishment and operation of farmer cooperatives and organizations in areas where past attempts by governments and institutions have failed.

For economic developmental strategies, it was felt imperative that attention be given to individual incomes and standards of living. Priority must be given to creating favorable environment for growth of private industries and to developmental projects that will increase employment and help improve per capita incomes It is necessary to institute laws and adopt policy measures (such as income taxes and welfare programs) that will reduce disparities in incomes. Such measures must be accompanied by programs to curb population, or else, resources cannot be effectively accumulated and used for economic development.

Most observers felt that the Green Revolution had demonstrated that community development and self-help programs had not contributed significantly to the progress made Some felt these programs may have been, in fact, counterproductive. This argument was based on evidence that innovation has resulted from outside economic forces that have drawn the farmers from out of their traditional trap and brought them into contact with the outside world through the market place Once drawn into this contact through economic incentives, they are influenced by what the outside world has to offer in innovative ideas, materials, and mode of life The peasant farmer becomes an economic man and his "felt needs" increase.

In contrast community development programs have not stressed the traditional farmer as an economic man. They have aimed at improving his physical and health environment through providing him with tools and materials that require more output from him without increasing his production and income. Thus, the programs have been counter-productive to agriculture through diversion of labor to projects that do not add to improvement of agricultural productivity.

In a similar manner, self-help projects have aimed at generating from within efforts for community improvement. In these efforts, despite hopes otherwise, the villager could not find a personal relationship or benefit. The villager's life

of Asia is based on personal relationships. Also, he looks to outside forces, his government, for attention and assistance, and is flattered by this attention, and affected by it. Furthermore, such self-help projects are also competitive for the villager's labor with production projects that generate income in kind or money.

### 11. SUMMARY OF SOME MAJOR POINTS FOR FUTURE WORK TOWARD AGRICULTURAL DEVELOPMENT

*The Entire Spectrum of Possibilities Opened by Breakthroughs Need Exploitation, Further Research and Development, and Attention to Problems Raised in Order to Realize Full Agricultural Potential*

Some major points for future work to accelerate agricultural progress toward realization of full potentials are summarized as follows:

a. diffusion of technology, especially to small farms who have been slow adopters, should be accelerated;

b. utilization of existing technology through adaptive research is needed to open new opportunities for infrastructure, i.e., land and water management and better uses for marginal lands (marginal for rice cultivation);

c. research on methods of land preparation and multiple cropping to combine with the new varieties is an important next step in follow-up on the successful introduction of the new varieties;

d. research and development for water management in the tropics, with agronomic input in irrigation projects, and water control in tropics, especially control of excess water, are also important factors to incorporate in agricultural programs and goals;

e. expansion of development and improvement of infrastructure, especially irrigation, transportation and marketing (processing, storage, and selling) will be required to further expand agricultural potential in most countries where adoption of the high-yielding varieties have already exploited the best lands and developed areas;

f. development and use of alternative crops suitable for lands lacking adequate supply or economic source of water is necessary for the "by-passed" people for social and political reasons as well as to provide most economic use of land and human resources;

g. careful examination of trained manpower requirements-educational matrix for professional, middle-management and technical levels for research, teaching, program planning, and implementation in government and private sector will be essential to fully develop agriculture and industries of LDC's:

h. successful adoption by farmers of new technology and a rationalization of a country's agricultural economy require adoption of support and stabilization policies that will permit favorable prices to producers and distributors to assure introduction and use of technology that can result in greater efficiency, thus paving the way for lower consumer food prices and permitting government programs to operate on sound economic basis in efforts to balance ebb and flow of supply;

i. diversification of agriculture is necessary to realize full potential of comparative advantages of areas and of the country, which requires examination of policies of "price economies" and self-sufficiency goals;

j. the successes with the new grains by a number of countries and future outlook call for attention to trade problems arising from increased supplies (staple foods), and development of bilateral arrangements and adjustment to internal goals that will assure full exploitation of any of the country's possible comparative natural and economic advantages.

## ANNEX 1

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AGRICULTURAL INNOVATION IN SOUTHEAST ASIA: THE IMPLICATIONS FOR DEVELOPMENT—SECOND SEADAG INTERNATIONAL CONFERENCE ON SOUTHEAST ASIAN DEVELOPMENT RESEARCH, JUNE 23–26, 1969, ASIA HOUSE—NEW YORK

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# APPENDIX II—BIOGRAPHICAL SKETCHES OF PARTICIPANTS

*Joel Bernstein* is assistant administrator of the Agency for International Development in charge of the newly-created Bureau for Technical Assistance. A Chicago-born economist with a doctorate from the University of Chicago, Dr. Bernstein has been associated with the foreign aid program for 21 years. He began his career in 1948 when he was connected with the Marshall Plan mission to the United Kingdom. Subsequently he served with AID and predecessor agencies in France, Italy, Liberia, Nigeria and Korea—in the last two posts as mission director. Before being named assistant administrator last September, Dr. Bernstein had served since 1967 as director of program evaluation in the Office of the AID Administrator.

*Lester R. Brown* is a senior fellow with the Overseas Development Council of Washington, D.C., and former administrator of the International Agricultural Development Service, U.S. Department of Agriculture. Mr. Brown holds degrees in agriculture (Rutgers University, 1955), economics (University of Maryland, 1959), and public administration (Harvard University, 1962). Recognized as a leading authority on the world food problem while still in his late 20's, he received the Arthur S. Flemming Award as one of the "Ten Outstanding Young Men in Federal Service" in 1965 and the Jaycee award as one of the "Ten Outstanding Men of America for 1966." The author of two books, *Man, Land and Food* and *Increasing World Food Output*, Mr. Brown entered the Department of Agriculture in 1959 where he served as an international agricultural economist and special assistant to the Secretary of Agriculture on foreign agricultural policy before being named administrator of IADS in November, 1966.

*Thomas F. Carroll* is chief of the agricultural economics section, Inter-American Development Bank, Washington, D.C., and adjunct professor of economics at George Washington University. A specialist in agricultural economics and rural development, Dr. Carroll received his advanced degree from Cornell University. He has taught economics at UCLA, the University of California (Berkeley), and the University of Chile. He also has done extensive field work in agricultural economics including service as FAO regional officer for Latin America (1960–1961) and as director, Research Program in Land Tenure and Agrarian Reform, Inter-American Committee on Agricultural Development (1965–1969). Dr. Carroll has written and lectured frequently on the agricultural problems of Latin America.

*Charles S. Dennison* has been a vice president of International Minerals and Chemicals Corporation since 1958 Born in New York City and educated at Columbia and New York Universities, Mr. Dennison has specialized in export and foreign trade since 1939. From 1946 to 1951 he was the export sales manager, Willys Overland Company; from 1951–1957 the managing director of Olin Mathieson Ltd. and E. R. Squibb Ltd., both in London; and from 1957–1958 vice president of the Chrysler Export Corp. A director of companies located in India, Senegal and Mexico, Mr. Dennison also is a director or member of a number of professional councils interested in agriculture. He is a member of the President's Science Advisory Committee Panel on World Food Supply and a trustee of the Agriculture Development Council.

*Orville L. Freeman* is president of EDP Technology International of Washington, D.C., and former U S. Secretary of Agriculture. Born in Minneapolis, a graduate of the University of Minnesota Law School, and purple-heart veteran of World War II, Mr. Freeman was a three term governor of his native state from 1954 to 1960. In 1961 he was appointed Secretary of Agriculture by President John Kennedy—at 42 the youngest man ever named to that post. Mr. Freeman served as Agriculture Secretary for eight years under two Presidents and supervised his Department's contributions to recent break-throughs in agricultural technology. On January 20, 1969, he became president of EDP Technology Inter-

national, Inc., a firm organized to bring about better management through the use of computer and systems technology.

*William S. Gaud* is executive vice president of the International Finance Corporation, Washington, D.C., and former administrator of the Agency for International Development. A resident of Greenwich, Conn., Mr. Gaud served on the staff of Gen. Joseph Stilwell in charge of lend-lease to China, India and Burma. With a degree from Yale University Law School, he worked as a trial lawyer in New York City before entering government service in 1961 as assistant administrator of AID for the Near East and Southeast Asia. He became deputy administrator of AID in 1964 and was named to the agency's top position in 1966. As AID Administrator he helped direct assistance funds into the agricultural sectors of less developed countries for the utilization of new high-yield grain varieties. He resigned his AID post in 1969 to take his present position with the IFC.

*Clifford M. Hardin* was sworn in as Secretary of Agriculture on January 21, 1969. Born on an Indiana farm, Dr. Hardin received a Ph. D. in agricultural economics from Purdue in 1941 and subsequently taught at the University of Wisconsin. In 1944 he moved to Michigan State University where he ultimately served as director of the MSU experimental station and held the position of dean of the School of Agriculture. In 1954 Dr. Hardin became Chancellor of the University of Nebraska. While serving in that capacity, he helped establish the new Attaturk University in Turkey and a program for agriculture in Colombia. He was president of the Association of State Universities and Land Grant Colleges in 1960 and has served as chairman of the American Council on Education's Committee on Institutional Grants Abroad.

*Lowell S. Hardin* is agricultural program officer for Latin America and the Caribbean for the Ford Foundation, New York City. He holds a doctorate in agricultural economics from Cornell University (1943) and has taught at both Cornell and Purdue Universities. From 1953 to 1965 he was head of the Department of Agricultural Economics at Purdue. He has been associated with the Ford Foundation's Latin American agricultural programs since 1965. Co-author of the book, *Farm Work Simplification*, Dr. Hardin is a director of the Agricultural Development Council, a member of the Panel on World Food Supply, President's Science Advisory Committee, and a member of the National Academy of Science's Agricultural Board.

*J. George Harrar* is president of the Rockefeller Foundation, New York City. Born in Ohio, Dr. Harrar received his doctorate from the University of Minnesota in 1935. After a distinguished career as a professor of botany and plant pathology, he joined the Rockefeller Foundation in 1952 as deputy director of agriculture. He advanced to director of agriculture in 1955, to vice president of the foundation in 1959 and to president in 1961. A noted agricultural specialist and administrator, Dr. Harrar's activities have brought him widespread international recognition and awards, especially in Latin America. He has served as a member of the President's General Advisory Committee on Foreign Aid. The author of *Strategy Toward the Conquest of Hunger* (1963). Dr. Harrar is a contributor to publications in fields of phytopathology and mycology.

*John P. Lewis* is the dean of Princeton University's Woodrow Wilson School of Public and International Affairs and the minister-director of the U.S. AID mission to India from 1964 to 1969. A specialist in political economy and government, Dr. Lewis received his Ph D. from Harvard in 1950. Following his graduation he became a staff aid with the Council of Economic Advisors but returned to teaching at the University of Indiana in 1953. From 1961 to 1963 he was chairman of the Department of Business Economics and Public Policy in Indiana's Graduate School of Business He was appointed a member of the Council of Economic Advisors by President Kennedy in early 1963 and served until the fall of 1964 when he undertook director of the AID program in India He served there until earlier this year when he was named to his present position. Author of *Quiet Crisis in India* (1962), Dr. Lewis has written frequently on economic development and planning.

*John W. Mellor* is a professor of agricultural economics at Cornell University, Ithaca, N.Y. and a specialist in the role af agriculture in economic development A graduate of Cornell, Dr. Mellor has taught there since 1952 and became a full professor in 1961 He has been an associate director and director of the Center for International Studies at the university, and spent 1963–1964 at the Indian Agricultural Resources Institute, New Delhi, as a visiting professor. A board

member of the International Voluntary Service (IVS), Dr Mellor is the author of *The Economics of Agricultural Development* (1966) and co-author of *Developing Rural India* (1968).

*Arthur T. Mosher*, president of the Agricultural Development Council of New York City, has been active in rural technical assistance since 1933. From that year until 1953 he was closely connected with the Allahabad Agricultural Institute in India, engaging in a number of experimental programs of extension methods. From 1953 to 1955, Dr. Mosher was visiting research professor of economic development and cultural change at the University of Chicago, from which he received a Ph. D. in 1946. At Cornell University from 1955 to 1957 as director of a seminar on comparative extension education, Dr. Mosher was appointed executive director of the Agricultural Development Council in 1957 and became president of the Council in 1967. The author of several books, the most recent being *Getting Agriculture Moving* (1966), he has written numerous articles on problems of agricultural development and served for several years as chairman of the Research Advisory Committee of AID.

*William C. Paddock* is a consultant to private firms involved in tropical agriculture and co-author (with his brother, Paul) of two widely-read books on world food problems, *Hungry Nations* (1964) and *Famine 1975!* (1967). After receiving his Ph. D. in plant physiology and breeding from Cornell University in 1950, he taught at Pennsylvania State University (1950–1953) and Iowa State College (1953–1955). From 1955 to 1957 he was agronomist with the International Cooperation Administration (ICA) in Guatemala, and from 1957 to 1964 was director and trustee of Escuela Agricola Panamericana, Honduras. From 1962 to 1965 Dr. Paddock was head of Latin American affairs for the National Academy of Sciences. Since that time he has devoted himself to his consultant work and writing. At present he is working on a book on "what makes an effective development program" planned for publication next year.

# APPENDIX III—"A FUTURE FOR RAM"

(Read before showing the film)

Răm (rhymes with "Prom") eldest son of Gopăl, lives in a Hindu farming village on the Ganges plain in North India. His father, like many peasant farmers in the underdeveloped world, still farms in the traditional manner of his ancestors. Gopal's farm yields only enough food to feed his family with a little left over to sell in the marketplace.

The highly successful Indian agricultural development program is available to the peasant farmers of Ram's village, and many of the farmers have already benefited from it. Maybe Ram's family will too.

As you watch this film, you will learn something of the aspirations and something of the frustrations of one farm family in the underdeveloped world.

(Script of motion picture)

A FUTURE FOR RAM

My name is Lakshmi. At least that's what I was called until my son was born. Then I became known as "Mother of Ram." This is how I will be known for the rest of life. I was proud to have a son.

I will live out my whole life here on the Ganges Plain in North India.

Most of my life will be spent in and around this house here in my husband's village.

Once in a while I will return to my parent's village for a visit. But I am satisfied here.

I have a good husband. His name is Gopal. He is a hard worker. We share a little land with my husband's brother. Gopal and I have enough for ourselves and our three children. Ram is our eldest child. He is in third grade in school. The barber thinks his hair is a bit unruly. So do I. He studies hard in school. I hope he will go far in life.

Shanti is the middle child. She is old enough for first grade, but she doesn't go to school. Somone has to take care of the baby. And besides, there isn't much reason for a girl to learn how to read. She will be married someday.

The baby is just over a year old. We haven't named him yet. He won't get a name for another year or so. So many of our babies die so young. I have already lost two babies. One died when he was born. The other died when he was two.

Shanti and the baby keep each other company much of the day. They play at home and they wander about the village observing the daily activities. Many things happen at the pond.

The washermen stand in the water and swing the wet clothes up over their heads and bang them down on the rocks.

On the other side of the pond, the villagers wash their water buffaloes. Sometimes a water buffalo gets loose in the pond Then someone has to get him out. This takes a lot of time.

The washermen chant as they work so the washing area is often a noisy place

The potter seems to be able to produce an endless array of cups, dishes, and what not from the lump of clay on his potter's wheel. He will make this clay into one of the large pots I use for carrying water on my head.

He lives near us and sometimes he gives Shanti a bit of his clay so she can make toys. She likes to pretend she has a stove just like mother.

Like most Indian women, I use cow dung in my stove. It's a smokey stove. but the smoke keeps away the mosquitoes at night and over the years it helps to discourage termites from eating away the rafters in our roofs.

Cooking is a long process, even though our meals are simple. I have to grind grain for our Indian bread, mix the flour, and I cook the vegetables when we have them. I wash the rice before I put it on the fire to boil. All this takes a lot of time.

We usually raise enough to eat, but we have little left over to sell.

While I am preparing supper Shanti watches the baby. Ram does his school work. He is a good student.

My husband Gopal often takes a bath while I am working on his supper. He takes at least one bath every day, even in the chilly air of winter.

I feed Gopal and Ram before I feed Shanti and myself.

After Shanti and I eat, and while I'm cleaning up the dishes Gopal amuses the baby.

Ram likes to play teacher with Shanti. *His* teacher says he would make a good teacher someday, if we can afford to send him on to Junior High School. I want him to have a good education. Then he will have a better life.

One night after supper, I decided to ask Gopal about this.

I told Gopal "I'm concerned about the future of Ram. I want him to get a good education."

Gopal said, "We are sending him to the primary school. He is getting a good education there. He will learn how to read."

But I argued that I wanted Ram to go to Junior High School where he can learn more.

Gopal said that Junior High School is very expensive. He didn't see how we can afford it. In Junior High School the students have to buy expensive books. And the tuition. "No," he said, "We could never afford it. Only wealthy people, like the big landholders, can afford Junior High School for their sons."

I pleaded with him "Couldn't we get more money somehow?"

That made him angry. "Mother of Ram," he said, "Already I'm working as hard as I can. I till the fields with my brother. And when there is no farm work to do, I join the men who make cigarettes."

He was very stern with me. He said, "You know that if I work hard all day long making cigarettes, I can earn enought to buy clothes, spices, and the tuition for sending Ram to primary school. But Junior High School, I'm afraid, is out of the question."

Well I was persistant. I told him I had heard that there are ways to grow *more* food on the land that we already have. I reminded him that the price of wheat is high. So is the price of rice. If we could only raise enough to sell some in addition to what we eat.

Gopal remembered a meeting he has been to and said, "Perhaps we could." At the meeting he had heard the government farm advisor talking about growing more food. The farm advisor had said that you need to use commercial fertilizer and new seed. But there were so many things Gopal didn't understand about the new way of farming. Making a switch like this would mean departing from the ways that have served our ancestors so well for so many generations.

There are so many things to do in our traditional way of living. I have to gather up the cow dung and make it into patties for cooking. I have to milk the cow, help with the harvest—and it seems like I'm always getting water from the pond or the well.

As I go about my daily chores now, I often think about that evening after supper when my husband decided to look into the idea of the new seed and the commercial fertilizer. He talked to his brother that very night. His brother said it would be all right provided my husband paid for the fertilizer and the new seed.

My husband then talked to so many people. He talked to the shepherd next door. He consulted the oldest member of our caste in the village and *they* talked together for hours.

He talked to the carpenter. The carpenter doesn't even have any land, but my husband wanted to find out everything anyone thought about the new seed and fertilizer.

Finally he went to the president of the village. The president has lots of land and uses fertilizer and new seed.

The president said the fertilizer and new seed would cost a lot of money—more than we had. But, the president said, Gopal would be able to get a government loan. First he would have to get a certificate from the Land Clerk showing that he owned land.

Gopal rode his bicycle to the Land Clerk's house 7 miles away. He talked to the land clerk about getting a land certificate. The land clerk said Gopal would have to come back tomorrow. Today the clerk couldn't work on the certificate because he was going to the district office. Gopal was disappointed.

Gopal tried three different days to get the clerk to make out the land certificate. The clerk was always too busy. Then a friend told him how to get the certificate.

The next time he went to the Land Clerk's house he gave the clerk some money. The clerk filled out the land certificate at once. At last we were getting somewhere!

The next day my husband went straight to the farm advisor's house in a nearby village to see what to do next. The farm advisor filled out a loan application. The application showed the amount of seed and fertilizer Gopal was entitled to purchase on loan.

The farm advisor told Gopal he would have to find two co-signers for his loan application. Gopal's brother and a neighbor agreed to co-sign.

The next week they went to the Development Office 5 miles away. The Assistant Development Officer accepted Gopal's loan application and showed Gopal how to sign the papers even though he didn't know how to write. After they had signed the loan application, the Assistant Development Officer told Gopal to come back in a couple of weeks to see if it had been approved.

The application was approved and the assistant development officer told him that the next step was to go to the seed store to pick up his seed and fertilizer. He told Gopal what day he should go to the seed store.

Gopal's day for getting the seed and fertilizer was about two weeks before planting time. He went to the seed store on the proper day but it wasn't open. He waited several hours as more and more disappointed farmers wondered what had happened.

In the afternoon, the seed store official showed up and explained that the store was out of both seed and fertilizer. They should come back again in two weeks.

During the next two weeks Gopal prepared his land for planting. Then he returned to the seed store to pick up the seed and fertilizer, for this was the time to put it on his fields. But the official said there were still no supplies.

He told Gopal, "Try again in a couple of weeks."

Now Gopal had to make a decision. Plant now with the old seed and no fertilizer or wait for the new seed and fertilizer. He decided to wait. For two weeks he rolled cigarettes. But when he stopped by the Seed Store again, there was still no seed or fertilizer there

So Gopal decided to plant. He could delay no longer. He used the same seed we have used for generations. It is reliable and will produce a crop if the weather is favorable.

Three months after the wheat was planted, Gopal got word that his seed and fertilizer had arrived.

By this time the crop was practically full grown. Now fertilizer would do no good. The crop was too mature.

He had to decide Should he go to the seed store and pick up the seed and fertilizer and have it on hand for the next season? If he did that, next season's crop would be better, perhaps, but unfortunately, he would have to pay off his government loan on the materials at the end of *this* harvest season.

Harvest wasn't far off. We could pay off the loan by selling some of this season's harvest. But then we would be short of food before the next harvest came. Gopal had worked so hard on the loan application he lost many days wages which he would have had if he had been making cigarettes. Therefore we had less cash on hand than usual at this time of year.

If Gopal were to pay for next year's fertilizer and seed with part of this year's harvest, he would have to go to the village moneylender before the next harvest season to get money to buy food. Gopal has never had to go to the village moneylender before. The moneylender's interest rate is very high.

He thought that perhaps he should refuse the seed and fertilizer he had worked so hard to get. Then there would be no loan to pay off.

Gopal decided to get the seed and fertilizer.

We harvested the grain. It was a good crop. Perhaps it would have been much more if Gopal had been able to use the new seed and fertilizer.

As I was winnowing the grain, getting it ready to take to market, I wondered if I had been wrong in pushing Gopal to try to grow more food. I don't want Gopal to be in debt to the moneylender. Once he counts out the money to you, you may be under his thumb for a long time.

But *maybe* we will be successful. *Maybe* next year's crop will be very good. *Maybe* we can use the new seed and fertilizer every year in the future, if we can only get started. *Maybe* we will be able to send Ram to Junior High School. I would be so happy. Perhaps then there will be a better future for Ram.

# APPENDIX IV—RESOURCE MATERIAL

## High Yielding Varieties of Grain

(By Dana G. Dalrymple)

(*Taken from* Technological Change in Agriculture: Effects and Implications for Developing Nations. *Foreign Agricultural Service, U.S. Department of Agriculture (in cooperation with Agency for International Development) April 1969, pp. 35–47. Footnotes and references are omitted here but are included in the original report.*)

During the late 1960's a great deal of public attention has been given to the role of improved varieties of wheat and rice in expanding food production in the less developed nations. Although some of the public statements have been overdone (e.g. "miracle seeds"), the new varieties have indeed brought about significant changes in agriculture.

### A. Background of New Varieties

Breeding for improved varieties of grains has been underway for many years in the developed world, but it is only since WW II that significant progress has been made in more than a handful of the less developed nations.

*1. Foundation-sponsored research*

National breeding efforts received a significant boost with the establishment of the Agricultural Program of the Rockefeller Foundation in Mexico in 1943. Emphasis was placed on developing improved varieties of corn and wheat as well as vegetables. Extension of the Mexican work subsequently led to the establishment of other programs in South America and India, and eventually to an International Wheat Program. The Central American corn project, established in 1954, grew into an International Corn Program. In 1966, the two programs were merged with the formal establishment of the International Maize and Wheat Improvement Center (CIMMYT—Centro Internacional de Mejoramiento de Maiz y Trigo) in Chapingo, Mexico. The Center, now jointly financed by the Rockefeller and Ford Foundations, presently has programs underway throughout the world.

Foundation interests in rice date back to 1952 when Rockefeller sent a preliminary study team to the Far East. It was subsequently decided that Rockefeller and the Ford Foundations would join forces to establish an International Rice Research Institute (IRRI) in the Philippines. The Institute was organized in 1960 and dedicated in 1962. Starting in 1965, scientists employed by the Institute and the Foundations were stationed at key research centers in other countries; they have become intimately involved with the research programs of the host nations.

Thus it can be seen that the two Foundation-sponsored efforts in grain improvement are closely intertwined with national programs. (AID has contributed funds to both centers to extend research and training programs.) Part of the main concept is that the Institutes do the "basic" research work, while "adaptive" research—tailoring of the variety to local conditions—is done at the national level. Not all the new grain varieties have been developed under this cooperative program, but a surprising number tie in in some way—through parent stocks, training of researchers, etc. Accelerated breeding programs are now underway at many points throughout the less developed world.

*2. Spread of new varieties*

There has been a sharp expansion in the area planted to improved varieties of grains in the less developed nations within just the last few years. Most of the increase has been in improved varieties of wheat and rice. Precise data are not available on the exact area planted, but a general picture for wheat and rice is provided in Table 2. Essentially all of the area reported planted to wheat and

rice is in Asia (primarily in India and Pakistan), but shipments of improved seeds have been made to many regions.

In India and Pakistan, plantings of improved varieties of corn and other grains expanded as follows:

[In acres]

| Crop year | Corn | Others [1] |
|---|---|---|
| 1966-67 | 563,000 | 388,000 |
| 1967-68 | 1,012,000 | 2,519,000 |
| 1968-69 (goal) [2] | (3,000,000) | (5,000,000) |

[1] Grain sorghum, spiked millet, and barley; almost entirely in India.
[2] Considerable shortfall expected because of dry weather

In some countries, plantings of the improved varieties represent only a small proportion of the total planted to that crop. In others it is beginning to reach an appreciable proportion: around 20% in the case of wheat in India and Pakistan in 1968. In any case, there has been a striking—possibly unparalleled—increase in the area planted to new varieties.

### B. NATURE OF TECHNICAL CHANGES

The use of the new varieties entails substantial changes in the agricultural functions involved and the technical base needed.

*1. Functions involved*

The main functional changes involved center around production, harvesting, and marketing. Improved varieties of grains require a "package" of inputs if they are to attain their maximum production potential. While any variety will respond to inputs such as fertilizer and water, they will do so only up to a point, and then diminishing returns set in. The new varieties have a much higher response threshold.

This is most easily seen with respect to fertilizer. Unimproved native varieties have only a limited response to fertilizer in terms of yield: much of the added growth goes into the stalk, which, as it becomes taller, is more apt to lodge (bend or break). On the other hand, the high-yielding varieties have semi-dwarf characteristics: as fertilizer is added, the response is in terms of grain yield, not stalk growth. Furthermore, the partly-dwarfed varieties have a stiffer stalk. Thus the point of diminishing returns becomes much higher for fertilizer.

TABLE 2.—ESTIMATED AREA PLANTED TO NEW HIGH-YIELDING VARIETIES OF WHEAT AND RICE IN THE LESS-DEVELOPED NATIONS

[In acres (rounded)]

| Crop year | Wheat [1] | Rice [2] | Total |
|---|---|---|---|
| 1964-65 | (3) | (3) | (3) |
| 1965-66 | 23,000 | 14,000 | 37,000 |
| 1966-67 | 1,554,000 | 2,343,000 | 3,897,000 |
| 1967-68 | 9,558,000 | 6,762,000 | 16,420,000 |
| 1968-69 (goal) | [4](14,750,000) | (12,300,000) | (27,050,000) |

[1] Essentially all Mexican or Mexican-type varieties. Excludes Mexico (where an average of 1,850,000 acres was planted to improved varieties during the 1960-64 period)
[2] Primarily International Rice Research Institute varieties (IR-8, IR-5), but also includes substantial quantity of (1) ADT-27 and Taichung (native) I in India, and (2) BPI-76 in Philippines. Does not include area planted to longstanding improved local varieties in Ceylon and Taiwan.
[3] Negligible.
[4] Plus an unestimated quantity of improved wheat in Nepal.

Source: Dana G. Dalrymple, "Imports and Plantings of High-Yielding Varieties of Wheat and Rice in the Less-Developed Nations," International Agricultural Development Service, Dec 17, 1968, 18 pages, as updated for India and Afghanistan. (The reference to wheat acreage in Mexico in footnote 1 was obtained from figures compiled by Reed Hertford of the Economic Research Service.)

The same is true of water. Consequently, most of the new varieties of wheat and rice are grown on irrigated land. Recently, however, a new dryland wheat variety has been developed (the wheat still requires water but can be planted

earlier and matures before the summer dry weather sets in). It, too, requires a package of inputs, including increased fertilization for maximum payoff.

Other inputs required include deeper plowing, drill or straight row planting (wheat), improved insect and disease control, more attention to weeding, better management, etc.

Even without adequate inputs, the new varieties generally slightly outyield native stock. It is reported that the new dryland wheat, for instance, will by itself increase yields 15 to 25% over older varieties. But if no provision is to be made for increased inputs for most of the new varieties, it may not be worth bothering with them. Thus the adoption of new varieties almost always goes hand in hand with the adoption of new cultural practices and new inputs.

Use of new production technologies also leads to a need for changes in harvesting and marketing. The new varieties, especially rice, are quicker maturing than native varieties. This means an earlier harvesting period; in the case of rice this can come during the wet season, which in turn steps up the need for improved drying equipment. Also the increase in yields can overwhelm existing harvesting and marketing techniques, creating a need for further changes.

*2. Need for technical base*

The preceding changes in functions must, to be carried out effectively, be built on a sound technical base. First, the seeds themselves must be available and of proper quality. High quality seed multiplication requires exacting technical and ethical standards. These are often difficult to meet under the conditions that exist in the less developed nations. Second, manufactured inputs must be available for production purposes. These include: (1) inputs for direct use such as fertilizer, insecticides and pesticides; and (2) inputs for the manufacture or application of the previous items (electricity or gasoline engines may, for instance, be needed to drive the water pumps for irrigation). Thirdly, manufactured inputs may be necessary for harvesting, drying, and storage of grains. In addition, improved communications and transportation may be essential. Thus, a fairly elaborate technical base—both in terms of knowledge and physical inputs—is necessary to capitalize on the new varieties.

### C. ADOPTION PROCESS FOR NEW VARIETIES

As with other technologies the adoption of new varieties has moved unevenly. Here we shall consider some of the major characteristics of the process

*1. Factors influencing rate of adoption*

The early adopters of the new varieties tend, as might be expected, to be better-than-average farmers They are also usually the larger farmers. In Mexico, for instance, wheat was most quickly adopted by the large, irrigated holdings of the commercially-oriented wheat farmers. This is not, however, always the case: in Kenya in 1967 about two thirds of the 300,000 acres planted to corn was in the lands of small farms, while in Turkey the 420,000 acres planted to wheat were divided up among approximately 60,000 farmers. All told, the new varieties are probably more neutral with respect to farm size than many other technologies

The rate of adoption of new varieties varies widely—both in terms of type of grain and farm and region involved. With respect to the grains, Mexican progress in wheat has not been matched by progress in corn; Indian progress in wheat has not yet been matched by progress in rice. Similarly, adoption has moved faster in some regions than others.

Barker has identified nine factors which he feels have influenced the rate of adoption of new rice varieties:

Water control
Insect and disease problems
Availability of complementary inputs (seed, fertilizer, labor, credit, etc.)
Quality of farm management
Farm institutional structure
Relative advantage of new over existing varieties
Acceptability of the quality of the new grain
Availability of marketing resources
Government institutional structure, pricing policy, and initiative

Water control is needed because the new shorter stemmed varieties cannot survive under flooded conditions: at present about 20% of the rice-growing area in tropical Asia is irrigated. More attention is needed for insect and disease control for any crop grown under intensive high-input conditions; moreover,

some of the varieties (particularly IR–8) may not have as much natural resistance as local varieties.

In some regions where the new varieties have been grown successfully for several years, the problems may take on a different complexion. Such is the case in the Thanjavur area of Madras state in India. There the expansion in the use of the new varieties may have hit a plateau because of problems of reviving an ancient irrigation system, tight official control over the rice price (the price in Madras City is reportedly the lowest in any major Indian city), uncertainty over land tenure, and problems in making improvements on rented land. Variations of some of these problems may influence the rate of adoption elsewhere.

*2. Role of government in adoption*

The major role in the spread of the new varieties has been played by the national governments of the LDC's in cooperation with IRRI, CIMMYT, and/or the Agency for International Development (AID).

National political leaders have taken a particular interest in the variety programs:

*Afghanistan.*—Former Prime Minister Maiwandal was so impressed with the production potential of the Mexican wheats and with the urgent need to arrest Afghanistan's growing dependence on imported wheat that he assessed each of the Ministeries 2.5% of its current year's development budget to create a fund to launch an accelerated wheat-production program.

*India.*—C. Subramaniam, former Food and Agriculture Minister, took advantage of the food crisis to mobilize support for and launch the accelerated food-production effort responsible for much of India's gains.

*Turkey.*—Prime Minister Demirel feels strongly enough about the crash program in wheat production, initiated at his behest less than two years ago, to have it directed and monitored from his office.

Vigorous support has also been provided by President Marcos in the Philippines and Prime Minister Senanayake in Ceylon.

The motivation for such support may not be entirely altruistic. In addition to obvious economic and social advantages to increased production, some political leaders see them as a path to re-election. At least such seems to be the case for President Marcos and Prime Minister Senanayake.

Government support has come at many levels—from exhortations to increased supplies of technical inputs. But because the new varieties require a "package" of inputs, the programs generally tend to be comprehensive in nature. This means accompanying the seeds with: increased quantities of inputs such as fertilizer, broadscale educational efforts, attention to increasing credit supplies, establishment of demonstration plots, initiation of price support and purchase programs, and many other steps.

In some cases these programs were virtually a cooperative effort of the national government and AID. Such was the case for rice in the Philippines, Vietnam, and Laos, and for wheat in Turkey. In the Philippines, among other activities, AID developed a do-it-yourself rice kit which has proved very popular. AID has also been connected with new variety introduction in other nations such as India and Pakistan.

Burma is somewhat an exception in that it has largely made its way alone. The route, if not the temper, has been much the same:

The government has exerted great efforts to induce the Burmese farmer to expand IR–8 production. It has lauded the qualities of IR–8, offered the farmer important material inducements, and mobilized the entire government apparatus and controlled press to support the program.

Once initial adoption is secured, continuing government support is necessary to keep the program going. The Philippines has, for example, developed a wide range of activities since 1967. Other nations may find it all too easy to let things slide.

*3 Permanency of adoption*

The adoption of new varieties is not a permanent thing. Growers may try a specific variety for a year or so and then decide to drop it with no particular capital loss.

Reasons for dropping a variety probably tend to center around economic matters. Two surveys of farmers in the Philippines who decided not to grow improved rice varieties another season indicated that over 50% of the reasons

were due to low price or added expenses; another 10 to 15% related to the added labor involved. A Burmese village reduced acreage because of the poor demand on both the free and black markets

But if growers should drop a variety, there is the possibility that they may continue to use some of the improved practices, with beneficial effects on yields. Moreover, it is quite possible that some of the growers may adopt subsequently improved varieties.

Thus for any one grower, use of new varieties does not represent a locked in technology, but one where there is, or is likely ot be, a continual state of flux.

### D. IMPACT OF THE NEW VARIETIES

The effects of the new variety package of technology are multifold. Some are quite apparent already; others are just beginning to emerge. Here we shall concentrate on the economic and social/political effects at the farm level.

*1. Economic impact*

Economic effects of the new varieties center about their effect on production and their consequent influence on financial returns.

*(a) Agricultural output*

The new varieties have had both qualitative impacts on output and have also influenced cropping patterns.

(1) *Quantitative effect.*—The increase in yields accruing from the use of new varieties is quite variable. It is one thing to talk about yields attained under experimental conditions or by top growers, and quite another to talk about average increases actually attained by ordinary growers (who may not fully follow recommendations). On the whole yield increases associated with the new variety package have probably averaged 50 to 100% if the comparison is drawn with conventional cultivation in the better growing areas. In other instances, of course, the increases may be quite different (and they might vary between wheat and rice).

Not all arable land is planted to the new varieties. In 1967/68, new varieties accounted for about (a) 6% of the area planted to rice in South and Southeast Asia and (b) about 16% of the area planted to wheat in South and West Asia. The proportions in individual nations varied widely. Just what percentage will be reached over the next few years will depend on a number of conditions. Since most of the varieties to date (except for the new dryland wheat developed in Lebanou) are grown to best advantage under irrigation, the area of irrigated land available will set an upper limit. The actual figure might well be less than this due to other cultural influences, as well as economic and social factors. On the other hand, the new varieties which have a shorter growing season will increasingly make double cropping possible.

Analyses carried out by the AID missions in India and Pakistan in mid-1968 shed some light on the role played by new variety technology. The studies were cast in terms of the factors contributing to the record increase in production in 1968 (1967/68 for rice) over 1967. Their relative influence was estimated to be as follows:

[In percent]

| | India | West Pakistan |
|---|---|---|
| High-yielding varieties including fertilizer and irrigation | 30 3 | 15.4 |
| Increased fertilization and irrigation of local varieties | 28.2 | 7.5 |
| Expansion of area | 6.2 | 30.0 |
| Weather (other) | 35 3 | 47.1 |
| Total | 100.0 | 100.0 |

It is not clear what portion of the expansion of area, if any, was due to the new varieties.

More generally, it has been estimated that during the 1968/69 crop year improved varieties may have increased rice output about 7% and wheat output 20% in the Asian area, compared to what production would have been without

them. As the area planted to new varieties expands they will, of course, play a greater role in increasing production.

(2) *Qualitative effect.*—In terms of demand, the new varieties of grains are often—if not nearly always—considered to be of lower quality than local varieties. There are at least three interrelated reasons for this: (a) genetic characteristics of quality may actually be less desirable, and/or (b) the new varieties may require improved methods of harvesting, drying and storing which are not as yet available, and/or (c) the difference may be more imagined than real. We shall look briefly at the first two.

Genetic characteristics of the grain may indeed differ. In the case of rice, texture and taste differences can lead to lower milling and eating qualities—influencing both domestic and export markets. Some of the Mexican wheats initially used in South Asia varied from local preferences in terms of grain color (they were red rather than white) and baking qualities. Breeding programs, however, are expected to solve many of these problems. Current rice varieties will soon be replaced with new strains developed at IRRI and elsewhere; an IR–8 cross with Basmati, for example appears promising for export purposes. Numerous white-grained types of wheat have been developed for use in South Asia. More are to come.

Problems with harvesting, drying and storing can arise from at least two sources. One is the fact that the sharply increased yields from the new varieties may simply swamp existing harvesting, drying and storage facilities; this in turn may lead to a consequent loss of grain quality. Or, as in the case of rice, there may be a problem of timing:

The IR–8 was harvested approximately one month earlier than local varieties during the end of the wet season. Rice sold wet in the field received a price discount well in excess of normal drying charges due to the risk involved in drying and milling before the rice spoiled.

To some extent, the difficulties involved with earlier harvesting of rice could be avoided if better equipment or facilities were available. But all too often they are not. Increased attention is being given to these matters at IRRI and elsewhere.

(3) *Influence on cropping patterns.*—The preceding quantitative and qualitative effects could have pronounced effect on cropping patterns.

In the short run, the increased returns available from the high-yielding varieties have in some cases led to a shift in production from other crops to rice and wheat. In India, for instance, during the fall of 1968 farmers appeared to show a preference for wheat while the area planted to some other crops such as gram, barley, and pulses showed a small reduction. Alternatively, short-term success with grains may lead nations to overlook other promising crops: one crop economist claims that in Vietnam, for example, preoccupation with rice has led to the neglect of bananas as a potential export crop.

Over the longer run, the increased output possible with the new varieties, and the impetus they give to multiple cropping, could well increase grain suppliers in some areas to the point where some land is freed or shifted to other crops. This appears to have occurred already among some rice farmers in the Philippines and wheat growers in Mexico (in the latter case, the shift was encouraged by the government's price support program). The other crops might well take the form of fruits and vegetables, or feedgrains for livestock production. In other words, the new varieties may in effect lay the ground work for the diversification of agricultural production.

### (*b*) *Financial returns*

The net returns to farmers from using the new varieties are influenced by changes in returns and costs. It was suggested in Chapter IV that increased returns are most likely to go to those who first adopt a technology, whereas later adopters may find little if any improvement. Our emphasis here will necessarily be on the shorter run.

(1) *Changes in farm prices and costs.*—The increased output associated with the new variety technology lays the base for increased income in the short run. The big questions concern the direction and magnitude of the price changes. These are directly determined by two factors: the quality of the product and the speed with which production increases.

There is, as we have noted, at least a temporary grain quality differential—one which has not favored the new varieties. In the Philippines, as of late 1968,

IR–8 rice was selling at about 20% below local varieties on the open market, even though the government buys at the same price. Out of 153 farmers surveyed in the Philippines during the wet season in 1967, 148 reported a lower price. In India, the reddish grain produced by the Mexican types of wheat often sells at 10 to 15% less than the best white grain Indian types. The international situation in late 1968 appeared to be particularly difficult for IR–8: one big sale made by the Philippines to India late in October was concluded at a price which reportedly represented a loss. Discounts for the new varieties are not, however, the rule in every market.

The price of grain is, of course, influenced by the quantity available—both nationally and on the world market—and the nature of demand. During the late 1960's world production of wheat and rice increased substantially. The demand for these two commodities, moreover, is generally inelastic. Thus it is not surprising that there was a decrease in some prices during the latter part of 1968. The FAO world export price index for rice, for example, moved as follows:

| | | | |
|---|---|---|---|
| January | 145 | August | 147 |
| February | 150 | September | 145 |
| March | 158 | October | 139 |
| April | 152 | November | 139 |
| May | 149 | December | 141 |
| June | 148 | (January | 138) |
| July | 149 | | |

Similarly, the wholesale price index for wheat in India during the June to November period was over 12% below that of a year earlier. Thus, while providing the basis for an increase in production, the new varieties also likely contributed to a drop in prices

In some of the less developed nations, the price drop was mitigated at the farm level by government price support and purchase program—such as that for wheat in India or rice in the Philippines. But this was done at no little strain to government treasuries. The Philippines, in fact, was led to propose an international rice agreement. Production increases in Mexico threatened to create surpluses and in 1966 the government reduced support prices for irrigated corn and wheat grown in leading areas.

The added inputs involved in the production of new varieties clearly will raise the costs of production per acre, though not necessarily per ton In one study in the Philippines, the increase in variable costs per hectare for growing BPI–76 and IR–8 instead of native varieties under traditional practices brought the total costs up by ½ to ¾; costs per cavan of output, however, were little different (and were less for IR–8). Comparable illustrative data are not at hand for wheat.

(2) *Changes in farm income.*—It has been widely assumed that the increased returns from growing the new varieties have exceeded the costs. Incomes have probably generally been increased in the short run. Yet there is little solid evidence on this point.

The returns on rice have not been uniform either seasonally or by market. Farm management studies on rice in the Philippines in 1967 suggested that net returns per hectare for IR–8 were two-thirds higher than traditional varieties during the wet season but only slightly higher during the dry season. The situation in Burma varies by market: as of late 1968 it was (a) profitable to raise IR–8 for sale to the government, because the purchase price was the same as for other types of rice, but (b) not profitable to grow it for the free or black markets because of a lack of demand brought on by quality problems.

Returns can also be viewed on a macro or micro basis. The gross value of the increased wheat production in Turkey during the 1967/68 season was estimated at $23.6 million, while total additional costs to farmers were placed at $18 0 million, giving very roughly a net return of more than $5 million. A linear programming study of foodgrain production in the Punjab in India in the land 1960's, however, suggested that net income per acre would not be significantly increased until fertilizer levels were increased substantially and capital was not a constraint. Much more study is needed on the nature of short- and long-run changes in farm income.

*2. Social/political impact*

Social/political problems can arise from the fact that certain groups may not share evenly in the benefits accruing from the new varieties. Within regions

there are farmers who may not adopt the new varieties because of economic or other reasons; similarly there may be differences in rate of adoption between regions. While those who adopt the varieties will face, as we have seen, further adjustments, their economic situation may well be better than those who did not adopt them.

Where this is so, there may be a growing or widening economic gap between sectors of the population. This may be less of a problem with the wheat and rice varieties than with more mechnical technologies because they can be relatively widely adopted. In Turkey, for instance, it has been reported that farmers who did not adopt the new wheats were ". . . those who because of inadequate rating could not borrow money, or those who were rational non-adopters . . ."

But there is an added dimension to the problem. Not all new varieties have moved as quickly as wheat and rice. Corn in Mexico is a prominent example. Although improved hybrid corn varieties were developed in Mexico along with wheat, a much lower portion of total area has been planted to them. Part of the reason is that corn is the staple crop of the small low-income farmer who usually doesn't have irrigation. Moreover, he may not have the opportunity or resources to buy new seed each year, not to mention the other inputs. The result has been that small farmers have largely been bypassed by technological change.

Technology is, moreover, apt to change much more rapidly than institutions. One of the most severe difficulties in many areas concerns land tenure arrangements:

Feudal land tenure relationships, which were successfully transformed in postwar Japan and Taiwan by decree, are proving wretchedly durable in southeast and south Asia. Unless legislation keeps pace with economic changes, the agricultural revolution will roll by leaving the rural population dispossessed.

The problem in many of these areas is that the pay-off from innovations is capitalized into land values, resulting in increased rents for tenants.

But the adoption of new varieties has not—unlike many new technologies—tended to directly result in the displacement of labor. If anything, it may have led to increased employment in the short run, especially in rice areas The same may be true over the longer run, particularly as increased grain production provides the basis for diversification involving labor-intensive crops.

If there has not been a sharp quantitative drop in employment, however, there may have been a qualitative shift in wealth. The farmers who have been the first to adopt the new varieties have been made, temporarily at least, financially better off. This increased wealth has not necessarily been passed on to the workers in improved wages. The result has been growing social tension in some areas. In the State of Madras in India, for instance, the uneven returns from the new varieties have led to serious clashes between owners or tenants and agricultural laborers: "Wages have increased unevenly throughout the district, and the landless laborers have been agitating for an even bigger share of the new prosperity."

The problem, as Mellor puts it, is that the new technologies may provide their benefits in proportion to landholdings rather than in proportion to labor inputs. Thus if social/political problems of the sort discussed here are to be avoided, landlords may have to adopt a more enlightened policy on land tenure, while farmers may have to provide more equitable wages for landless laborers. Neither will be easily accomplished.

*3. National and international implications*

We have discussed the effects of the new variety technology largely in terms of their influence with respect to agriculture. There are, of course, many potential effects at the national and international level.

At the national level, supplies of grains will be increased and prices reduced. Depending on the degree to which marketing and food distribution are improved, the result may be a reduction of undernutrition. To the extent that increases in grain supplies permit increased production of other crops, there may also be a reduction in malnutrition. The improvement in nutrition, together with the possibility of reduced imports and increased exports, will contribute to national economic growth. The results, however, may not be favorable: the temporary increase in consumer income (due to lower prices) and in the income of at least some farmers has caused concern about inflationary pressures in at least one nation.

Impacts at the international level may be more complex, particularly with respect to trade. As less developed nations increase grain production, they will

first move to economic self-sufficiency and then possibly into an exporting situation. Self-sufficiency will mean a reduction in dependence on foodgrain imports—especially those of a concessionary nature; this in turn may create some short-run adjustment problems for food grain exporting nations (though over the longer run, with economic development, the market for some agricultural products may improve). But as the less developed countries move into the international grain market for grain, they will face a host of new and sophisticated problems—involving questions of product quality, comparative disadvantage, trade barriers, etc.; in this market the established exporters may well have the edge. Issues of this nature will doubtless be of increasing concern.

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## The Role of Research in the "Green Revolution"

(By Edwin M. Martin)

*(Edwin M. Martin, Chairman of the Development Assistance Committee of the Organization for Economic Cooperation and Development, has served with the Department of State for almost 25 years. Prior to accepting the DAC chairmanship in 1968, he was U.S. Ambassador to Argentina for four years. He has also held the positions of Assistant Secretary of State for Inter-American Affairs, Assistant Secretary of State for Economic Affairs, Deputy U.S. Representative to the North Atlantic Council, and a host of others. This article originally appeared in* War on Hunger, *a report published monthly by the Office of the War on Hunger, Agency for International Development, Volume III, No. 9; September, 1969.)*

Future economic historians may well choose to refer to the decade of the 1960's as the decade of the "Green Revolution". For what has started to happen to rice and wheat and corn productivity in a number of tropical countries may be the start of a major transformation in the well-being of some two-thirds of the world's population whose economic fortunes are largely determined by how much their human resources and their soil and water can be made to produce.

If future developments justify such a label, the responsibility and credit will go in large measure to the scientists in agricultural research institutions who have devoted their energies and abilities to focusing all man's understanding of the scientific principles of genetics, soil chemistry, plant pathology, entomology, etc. to the single purpose of increasing the productive return from each seed planted

### TEAMWORK FOR REVOLUTION

Of course; the new germ plasms in their miracle seeds would be unheard of outside of experiment stations if many other factors were not playing their parts. Governments, with help from foreign countries and private investors, have to use scarce resources, especially foreign exchange, to see that controlled water supplies and adequate quantities of fertilizer, insecticides and pesticides are available to farmers when they are needed at prices they can afford to pay.

Just as crucial has been the transfer to millions of individual farmers, the majority illiterate, of the techniques worked out by the researchers for combining all these ingredients to secure the optimum results. To justify the inputs, they must be treated almost like a new crop, abandoning ways that have been endorsed by generations of use.

The incentive to risk much, sometimes all, in such an experimental venture must come from an exceptional prospect of profit, resulting from a favorable ratio between added input costs and the added value of a larger crop. It is here that superb teamwork between a few enlightened governments who have guaranteed minimum prices or subsidized inputs, or both, and the researchers who have made available a package of new inputs (seeds, fertilizers, etc.) combined with new agronomic practices capable not of increasing output 10 or 20 or even 50 percent but of doubling or, with multiple cropping, trebling or quadrupling it, has shown the way and inspired the claim of "revolution". For farmers, no matter how ignorant of the world or how tradition-bound to the ways of their ancestors, have in country after country shown beyond doubt that they could count, and that the prospect of large increases in profits has the same chain-breaking qualities it has had elsewhere in the world's history. In these circumstances motivation has been no problem.

It is necessary, though, to keep it operating by preserving the cost-price ratios at an adequate level, especially by seeing that there are market channels by which the additional foodstuffs produced can be sold at a fair price, or, from the consumer point of view, that more people eat better.

## FUTURE RESEARCH ROLE

What then is the future role of agricultural research? Has it done its basic job? Can extension services plus sound government policies carry the load from here on? The answer is an emphatic no.

It is, of course, unlikely that such long leaps forward as those made in recent years will again be possible for wheat and rice. But much remains to be done.

Present high-yielding varieties are dependent on relatively large quantities of carefully controlled water supplies. The limit of acreage on which they can be planted will soon be reached; it is capable of only slow and expensive expansion by new irrigation systems. At the rate population is growing, and is sure to increase for several more decades despite what can be achieved by family planning, there won't be enough cereals unless productivity can also be greatly increased where such ideal water control is not available.

## SORGHUM, MILLET, CORN

This is a question not just of new breakthroughs with wheats and rices but with dry-land grains such as the sorghums and millets. Although it proved impossible to transfer excellent varieties of wheat and rice from temperate to subtropical and tropical zones, the tremendous amount of knowledge about thousands of varieties of these two grains which has been accumulated by several generations of researchers was the essential basis for the apparently sudden breakthroughs which have been achieved. No such reservoir of scientific experience exists for sorghum or millets and hence much more work is almost certain to be required to achieve comparable results.

I have postponed further discussion of corn because it seems to present the special problem of not only being unadaptable from one major climatic zone to another but of not being transferable without substantial loss of productivity from one part of the tropics or subtropics to another. Breeding of high-yielding varieties therefore has to be highly decentralized and many times duplicated. Moreover, really good results have only been secured thus far with hybrid seeds which are difficult to keep flowing in pure form to millions of small farmers. The importance of corn as a food in many parts of the world requires that this duplicative research effort proceed with all energy.

Here too there have been some promising results in adding to the protein content, thus providing without doubt that the cheapest and most easily achieved major reduction in protein deficiencies now in prospect. This had added importance as we learn more about the life-long effects of protein deficiencies between weaning and about six years of age on mental and physical capacity. Eliminating such deficiencies would represent a major investment in future economic growth as well as individual welfare.

## AGRICULTURAL PRIORITIES

Grains deserve first priority because of their general cheapness and acceptability as the basic source of calories and often of proteins. But they are not sufficient to meet all needs, especially for proteins, and growing conditions as well as eating habits give importance to other food crops. Next in priority are probably the grain legumes and the root crops. Except for soy beans, and that only under temperate conditions, the research possibilities have been hardly explored, let alone exploited. Here again, starting almost from scratch, we must expect a major research investment for a period of about ten years before asking for a report on results. If significant progress comes sooner, we should express our surprise and pleasure.

As living standards continue to rise in the developing countries, demand will grow for the variety offered by fruits and vegetables. Good nourishment also justifies their playing a larger role in the daily diet. As grain productivity begins to meet needs on fewer acres or in a shorter growing season, more acreage will become available for these items. Here again we face an almost blank page as far as basic research on the genetics or cultural requirements of most tropical fruits and vegetables are concerned, the only exceptions being major export groups like citrus. Breeding is, of course, an especially prolonged process for tree-borne fruits. It is therefore urgent that a major start be made now.

The need for starting immediately in a major way on all these tropical crops is underlined by the fact that in contrast to wheat, rice and corn, the developed

countries have almost no first-class scientists knowledgeable enough to take leadership in training a research team, let alone having a whole team.

Last in priority but incapable of neglect are the impediments to larger output of animal products. Some argue against encouraging this sector on the grounds that in a poor society one cannot afford the inefficiency of animals in converting vegetative matter into calories and proteins for human consumption. Opponents of this view contend that some portion of human protein intake must be in animal form if malnutrition is to be eliminated. Neither are correct views. There are large land areas which for one reason or another cannot produce grains or other green crops for humans but can support animals. On the other hand, it is possible, though not always easy, to get an adequate balance of proteins solely from crops, with no animal supplements.

In any case, animal raising is an integral part of many social systems. Many people want to eat animal products and as incomes rise will do so increasingly. These are unavoidable facts. I conclude from them that it is only reasonable to put our scientific knowledge to work in order to make the inescapable activity of animal husbandry more efficient—to raise productivity.

## GENERAL RESEARCH PROBLEMS

The most critical problems are those of waste due to tropical diseases and pests, about which all too little is yet known. There are also many aspects of animal management in the tropics about which we have much to learn. Especially important is the development of improved types of tropical forage, again a field on which developed country scientists have had little reason to spend much time though some good work is going on in northern Australia.

In addition to the preceding types of product specialization, there are several general problems of such across-the-board importance as to deserve concentrated research efforts. Undoubtedly the most critical, already alluded to, is the handling of water. How best to get more where it is scarce? How to get rid of it where there is too much? How to economize in its uses? These are just a few of the problems. In many countries the major problems have factors in common, but in details they are everywhere distinct, and a coordinated scientific attack urgently needs to be mounted.

Shifting cultivation, often (but not always) slash-and-burn procedure, is widely practiced in almost all bush and forest areas of the tropics in low land and mountainous regions. Some shifting cultivation systems have left cropped land (after three to five years of cultivation) fallow for as long as ten years. Population pressures, created by post-war reductions in death rates, are eroding the length of fallow and with it the fertility of the soil. Ways to maintain soil productivity with more or less continuous cropping will not be easy to find because of both the leaching action of the heavy tropical rainfall and the poor basic quality of the soils in many of these areas. But they are so extensive on all tropical continents that scientists must find a new response to the situation which is at least as satisfactory, hopefully even better, than the relatively sound one which traditional society worked out for its situation of very low people-to-land ratios.

## REDUCTION OF WASTE

Some also think intensive research is warranted in the kinds of crops and animals that can be grown and on cultural practices in areas which seem certain to be always arid, with considerably less than normal rainfall and no ground or surface water sources for irrigation.

Others have suggested concentrated research effort on the reduction of waste by rodents and birds, serious problems to which no truly efficient answers have been found.

Storage under tropical conditions is another waste problem to which the recent sharp increase in productivity have attracted more attention, rightly though belatedly. Some estimates suggest wastage of grain between harvest and consumption of as much as 25 per cent in many countries, a rate we cannot afford not to reduce.

In all these areas of research activity it must be reemphasized that there is a vital role not only for major international research centers to conduct basic research to solve current production and distribution problems but also for regional and national centers to do breeding to meet local production and consumption conditions and to determine the best local cultural practices in the light

of the cultural environment and available agricultural inputs. All must be supported. In both cases real success will, as always, depend on a close liaison with farmers to insure that the right problems are given priority and that research results are put promptly into practice.

Some research is being done somewhere on most of the problems listed. However, it is seldom adequate in scope or intensity. In particular, the research leadership required from a high-level team of outstanding men, well-financed and managed, is not presently available for grain legumes or root crops, fruits and vegetables, water management, predator control, or arid systems and only partially for animal husbandry.

### QUALIFIED LEADERSHIP NEEDED

What is needed? As always one needs money, but really not very much. When one looks at the hundreds of millions of dollars being committed each year to agricultural development by both donors and recipients, and reads some of the well-known studies of rates of return on investment in agricultural research, the wonder is that money isn't looking for people rather than vice versa. To invest so much without adequate prior research to maximize the real return on investment is a "traditionalist" approach, an anachronism in an age which owes its riches to the application of scientific and technical knowledge to the conquest of our natural environment.

Actually, if bilateral and multilateral donors could build up to a contribution of $50 million a year by the end of five years we could have first-class international research institutes operating on all the major problems. They could also be giving substantial training and advisory help to an extensive network of regional and national centers as well.

It will take this long primarily because of the need to find, and in many cases to train, qualified research staffs. Nothing is scarcer than first-class brains, especially if they must also be capable of operating as team members and teachers as well as scientific investigators. Nor will it do to try to get along by borrowing experts for a year or two, except as specialized supplements for a hard core team of dedicated permanent scientists, prepared to devote five or ten years or a lifetime to this rewarding task.

Finally, it is equally vital that the organization and management of such centers be such as to permit the scientists to spend their time at high priority tasks directly related to agricultural productivity. Research center directors must be free from political interference and yet close to political authorities, through whom their results must go to reach farmers. They must be free to apportion funds flexibly as new problems arise and to insure a proper balance between laboratory work and field testing. They must not only be free to operate in this way but able to do so wisely. Probably the hardest job of all will be to find qualified direction.

With such a joint effort of developed and developing countries, we can expect a transfer of science and technology of the most fundamental importance, dealing with the industry on which the vast majority of people depend for a livelihood. No greater contribution can be made to the long-term prospects for self-sustaining growth which is the basic requirement for true independence as well as the well-being of all classes, but especially those who are now most in need.

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## Antifamine Strategy: Genetic Engineering for Food

(By Sherret S. Chase)

*What can genetics do to increase food resources? One answer is visible in the rapid spread of dwarfing genes from a Japanese wheat variety called Norin 10. With these genes, short-stemmed wheat varieties have been engineered which yield more harvestable grain under intensive cultivation in many parts of the world. This is one aspect of genetic engineering to increase the food supply of the rising world population. Prof. Chase, a plant geneticist of the State University of New York and the Botanical Museum, Harvard University, describes others from the plant breeder's point of view.*

As the civil engineer, part artisan and part applied physical scientist, designs and constructs physical structures, in similar fashion the plant breeder, an engi-

neer also, part artisan and part geneticist, defines his objectives and manipulates the plant materials available to him to realize his goals and those of society.

Plant breeding predates Mendel. Many productive plant breeders of the past, even the very recent past, had scant knowledge of genetic theory. Today the productive plant breeder draws heavily on the science of genetics and may himself engage in fundamental studies.

Though the plant breeding profession can take pride in its accomplishments, the world situation requires greater efficiency not only toward improvement of the food grains, but also of almost all the plants cultivated for man's use: the fiber, pulp and timber species; the vegetables; the beverage plants; the oil, latex and drug species; the forages; and the ornamental trees, shrubs, foliage plants and herbs.

Most promising is the recent increased internationalization of plant breeding through inter-governmental programs, the activities of the philanthropic foundations and the commercial expansion of the private seed companies. Internationalization, so far, has resulted in greater efficiency of effort, a change of particular importance to underdeveloped regions.

## GRAIN, THE SUSTAINER

Historically, presently, and for the foreseeable future, the food grains are the crop plants most important to man (for recent world production levels, see Table I). With sugar cane, another member of the family of grasses, they furnish the bulk of his carbohydrate requirement and, directly or indirectly, a large percentage of his protein needs. Rice is most important. According to Paul Mangelsdorf, former director of the Harvard Botanical Museum, "At least 50 per cent of the world's people get at least 60 per cent of their energy from rice. Thus, more than 30 per cent of all the human energy on the globe now comes from one plant species, the rice plant." This dependence is likely to increase in the near future, due to the rapid growth of population in the major consuming areas. Next in importance, though greater in tonnage produced, is wheat, then, in order, corn (maize), barley, the millets and sorghums, oats and rye.

TABLE I

| Grain crop | World production, 1966[1] | | |
|---|---|---|---|
| | Area in million hectares | Yield in 100 kg. per hectare | Production in millions of metric tons |
| Rice | 126.2 | 20 0 | 253.1 |
| Wheat | 217.2 | 14·2 | 308.3 |
| Maize (corn) | 102.3 | 23 3 | 238 8 |
| Barley | 70.2 | 16.5 | 116 0 |
| Millets and sorghum | 112 1 | 7 6 | 84.7 |
| Oats | 30.7 | 15 8 | 48.5 |
| Rye | 24.1 | 12.9 | 31.0 |
| Total | | | 1,080.4 |

[1] Data: U.N Food and Agriculture Organization.

In the subsistence regions of the world, food grains are consumed directly by man; in regions of affluence or surplus, a large percentage of the crop is fed to livestock and poultry.

## GENETIC ENGINEERING

An individual, whether man or crop-plant, is the product of genotype-environment interaction. In plant breeding, goals cannot be set unless the cultural environment is more or less well defined. Conditions of nature—the day-length, temperature regime, rainfall—are important. So are the more controllable cultural conditions—the level of fertility, availability of irrigation water, the adequacy of husbandry, and the plant population per unit area. The plant breeder has learned from experience to breed crops for the better rather than the poorer or average farmer, for improved cultural practices rather than subsistence practices. By no means are all the problems of the breeder concerned with performance in the farmers' fields Also important, often decisive, are problems related

to seed production and distribution, and the needs or requirements of the market and ultimate consumer. A great deal of effort is devoted to genetic solutions of seed production problems in those crops which are hybridized. For example, no matter how desirable and productive hybrids may be, they cannot help the farmer unless hybrid seed of good quality can be produced in volume at low cost, with a margin of profit for the seed producer.

### GENETICS—KEY TO PLENTY

In my opinion, the gentic engineering of the major food grains is one of the most exciting things man is doing today. With its necessary complement, the development and implementation of population control, it may well be the most important. Considered in terms of absolute costs and absolute profits, the genetic enhancement of food plants is the best of investments.

The challenge to the plant breeder is evident from the comparative regional yield levels per unit area of rice, wheat and corn given in Table II (Note particularly the relative levels of yield in South America, Asia, and Africa.)

### ELEPHANT'S EYE

In all the food grains there are major efforts underway to restructure the plants to make them better adapted to high levels of production per unit area under conditions of intensive culture. Three attributes are receiving particular attention: plant height, stiffness of stalk, and leaf arrangement. Short plants, stiff-strawed, with upward extending leaves are favored, as these seem more able to withstand high levels of nitrogen fertility and higher plant densities than are tall plants or plants with lax, drooping leaves. Upward extending leaves seem to be more efficient in energy gathering—in photosynthetic efficienoy—when plants are crowded close together than are lax, drooping leaves. Short, stiff-strawed plants are also better suited to machine cultivation and combine harvesting.

The corn farmer in the United States and his counterpart elsewhere does not want corn "as high as an elephant's eye." He wants short, lodging-resistant plants, easily machine harvested, 16,000 to 24,000 or more of them per acre, each producing a well-formed ear. In the north, ordinary corn is short enough; in the central Corn Belt short-statured hybrids are replacing the taller corn of the recent past. In the South and in tropical regions where corn normally is very tall, dwarfing genes, such as the recessive brachytic-2, are being introduced rapidly to commercial varieties and hybrids to achieve drastic shortening of the stalk. Brachytic-2 results in a telescoped form of the plant, with as many leaves as a normal counterpart but much less height. With such dwarfing, for photosynthetic efficiency, the desirability of genotypes with upright leaves increases.

In grain sorghum, a whole series of dwarfing genes has been recognized, and used, to produce short plants. The increase in sorghum culture in the United States traces directly to the utilization of these dwarfing genes to produce varieties well adapted to combine harvesting. Grain sorghum production here has increased approximately 15-fold since the 1920s.

TABLE II

| | Relative yields of grain per unit area in crop, as percentage of highest[1] | | |
|---|---|---|---|
| | Rice | Wheat | Corn |
| North America | 67.9 | 80.4 | 100.0 |
| South America | 32 6 | 54.3 | 38 2 |
| Western Europe | 100.0 | 100.0 | 82.8 |
| Eastern Europe | 53 5 | 99.1 | 68.0 |
| U S S.R | 50 0 | 47.5 | 67.7 |
| Asia | 34 6 | 38.9 | 31 5 |
| Africa | 30.8 | 32 0 | 30.3 |
| Oceania | 94 5 | 65.9 | 65.1 |
| World | 35.1 | 57.6 | 60.9 |

[1] Adapted from 1966 Data, U S. Department of Agriculture "Agricultural Statistics," 1967 edition.

### ENGINEERING RICE

Many landraces of rice are five to six feet tall with drooping leaves. Research conducted in Japan indicates that stiff, short-statured, upright-leaved varieties of rice with tillering ability have the greatest yield potential under intensive cultivation. Varieties have been bred to these specifications. Particularly productive have been a series of short-statured, stiff-strawed varieties from Taiwan. These, about 40 inches tall at maturity, have produced exceptionally high yields at very high levels of fertilization. Improved versions, the product of intensive breeding and selective work at the International Rice Research Institute (IRRI) in the Philippines, are now moving out into many rice growing regions of the world. Some may be used directly, others will serve as breeding material for development of locally adapted, short, stiff-strawed, upright leaf varieties. In the Philippines, one of these, IR 8, averaged 80 per cent more grain than local strains—a result of being able to utilize 90 pounds more of nitrogen per acre without developing major lodging problems.

Well publicized have been the short, stiff-strawed wheats recently developed in Mexico. These have helped make Mexico self-sufficient in wheat. Mexico wheats and their derivatives are revolutionizing wheat culture in many parts of the world. The story is the same: short, stiff-strawed wheats with upright leaves respond more successfully to high culture than the local kinds they are replacing.

The dwarf wheat "Gaines," developed at Washington State University, in the period 1949 to 1961 by O. A. Vogel, and "Nugaines," another derivative of the cross of Norin 10 by Brevor, were used to plant about two and a half million acres of the wheat acreage of the Pacific Northwest in the 1967 and 1968 seasons. Many yields in the range of 150 bushels per acre were recorded. One farmer obtained a yield of 209 bushels per acre, the world record for wheat (the U.S. average was about 26 bushel per acre).

### MEXICAN WHEATS

The Japanese, effective plant breeders in many fields, have recognized the advantages of dwarf wheats for years. Norin 10 was registered and released in 1935. As is true of many Norin 10 derivatives, the variety is not only short with stiff straw but produces more tillers (separate flowering stalks) than is usual among other stiff-strawed varieties. European wheat breeders have also long appreciated the advantages of short, stiff-strawed wheats. In Italy, Japanese wheats were used in breeding programs from 1911 on, if not earlier.

The present surge of world interest in the dwarf wheats has gained impetus from the outstandingly successful work of N. E. Borlaug and his associates in the cooperative wheat improvement program of the Mexican Ministry of Agriculture and the Rockefeller Foundation, initiated in 1954. Improvement was dramatic. In 1943, average wheat yields in Mexico were 11 bushels per acre: half the wheat needed was imported. By 1964, 37 bushels per acre were being produced in Mexico on the average, and the country had wheat available for export.

### MORE IMPORTS

In 1965, Pakistan bought 350 tons more imports of Mexican dwarf wheat for seed. These 350 tons planted 12,000 acres where they yielded a 50-fold increase, four times the normal Pakistani yield. From the increase 300,000 acres were planted, including 35,000 one-acre demonstration plots in 18,000 villages. In 1967, Pakistan imported 42,000 additional tons of Mexican dwarf wheats. These new varieties have helped end a 20-year food grain deficit. Thought is now being given to use of surplus wheat lands for other purposes.

In India, 18,000 tons of the Mexican wheats were imported in 1966. In the 1967–68 season, six million acres were sown to dwarf wheats, 18 per cent of the wheat acreage. This 18 percent produced much more than its proportionate share of the total crop—an estimated 40 per cent.

The dwarf wheats have given a fertilizer response in Mexico, India and Pakistan of the order of 17 to 30 pounds of grain for each pound of nutrient furnished, as compared to 11 to 16 pounds per pound of nutrient for the local unimproved kinds. Though the Mexican varieties have done well, similar locally bred varieties may do better in resisting local diseases and in satisfying the local market. Unfortunately, the red-grained Mexican varieties such as Lerma Rojo

64, PV 18 and Sonora 64 sell well below the price of the white-grained local varieties. Such color preferences are restrictive in regions where food grains are used directly for human consumption. These and other culinary characteristics and milling properties must be taken into account by the breeder along with gross yield and agronomic characteristics.

## THE WHEAT GAMBLE

The massive importation of Mexican dwarf wheats into India and Pakistan was a major gamble: a brilliant one we can say, since it paid off. It could well have failed. The gamble was made necessary by the inadequate support of wheat breeding and agriculture generally in India and Pakistan in the past. The sort of effort undertaken in Mexico should have been underway in India and Pakistan at the same time or earlier.

Both India and Pakistan have first-rate plant breeders. Yet wheat breeding as a necessary task was not adequately supported by the Indian or Pakistani governments or, before partition, by the British. The result was that the imminent threat of famine forced the gamble of importation of vast quantities of the Mexican dwarf wheats, wheats known to be of a grain color disliked by the local population and known to be susceptible to endemic plant disease. Plant breeding is now more highly regarded in these two countries; it is indeed becoming an honored profession.

## QUEST FOR RESISTANCE

The quest for genetic resistance to attacks on plants by disease organisms, insects and other pests is unending. For years, the wheat and oat breeders were concerned with little else. Control of pests through genetic resistance of the host is usually more economical than control by chemicals. It may also be more certain, and it avoids the dangers of environmental pollution by pesticide residues. Consequently, resistance to rusts and other fungi, and to insect damage, is bred into the cereal plants when possible. In some cases, the products of such breeding efforts have been highly successful in withstanding the attacks of pathogens. In other cases, the results have been disappointing.

Losses from disease and insects are immense. According to Elvin C. Stakman, professor emeritus of the Institute of Agriculture, University of Minnesota, "The control of pests and pathogens of the principal cereal food grains—wheat, rice, maize, sorghums and millets—would add 200 million tons annually to the billion tons now produced." At the subsistence level of human existence, outbreaks of plant disease can be catastrophic. More than a million people died in India in the 1940s in direct consequence of *Helminthosporium* blight of the rice crop.

In one of the most remarkable feats of genetic engineering accomplished to date, E. R. Sears transferred a small segment of a chromosome of *Aegilops umbellulata*, carrying a major gene for leaf rust resistance, to common wheat. Common wheat, *Triticum aestivum*, is an amphidiploid containing the full chromosomal complements of its three ancestral species. *Aegilops umbellulata* is a diploid. Attempts to cross the two species directly failed, but both can be crossed with *Triticum dicoccoides*; emmer wheat. By use of this species as a bridge, Sears obtained plants with all the chromosomes of common wheat plus one from goatgrass, the chromosome carrying the resistance factor. These plants are irradiated prior to sex cell formation. Among some 6,000 progeny, one plant was found that had a minute chromosomal translocation involving the desired gene for resistance. This plant was fully fertile and provided the desired source of leaf rust resistance for breeding work.

## IMPROVING NUTRITIVE QUALITY

The cereal crops of the world are deficient in the essential amino acid, lysine, and other amino acids as well, as measured by human requirements. But legume seeds—soybeans, peanuts, beans and gram—are rich in lysine. Use of legume seeds as a dietary supplement is common among grain eaters throughout the world. Consider the corn and beans of the American Indian, the peanuts and sorghums or millets of the African, the use of gram and other pulses as part of the diet in India. At the subsistence level, however, protein supplements tend to be absent from the diet of babies and young children and inadequate in amounts for adults. Children in early life are particularly vulnerable to amino acid deficiencies.

Two recent developments have stimulated breeding for improved protein. One is the simplification of devices for measuring amino acids by kind and quantity.

The other is the discovery by Mertz, Bates and Nelson that a recessive corn gene, opaque-2, mediates the development of corn protein with unusually high levels of lysine and tryptophan. Another recessive gene, floury-2, seems to have somewhat similar favorable effect on the balance of essential amino acids. The flour corns, highly regarded by the Indians of North, Central and South America but largely ignored by modern agriculturalists, may be worth attention.

These varieties of indigenous corn as well as others are being carefully screened, as are genetic mutants and modern commercial corns. Variations in the amino acid balance of the sorghums have been established. Certain strains of wheat have higher quality protein than others. A strain of oats with protein of unusually high quality has recently been discovered. These developments are promising. If the balance of essential amino acids in the food grains can be substantially improved without loss of total food energy productivity, this will set the stage for a great gain in the struggle against starvation and malnutrition.

### ADAPTIVITY

In all grains, early maturity of crop is favored by farmers, provided yields are satisfactory. Use of short-season grains may make possible double or triple cropping. This is the major impetus for development in early maturing varieties of rice. In Italy, an appreciable acreage of corn is planted in June after wheat harvest. Short-season, heat-tolerant hybrids make this type of double cropping feasible. In certain tropical regions with long wet and dry seasons, drought-resistant sorghum and water-requiring rice form successful double cropping mates, provided the varieties mature early enough. In India, use of hybrid corn has been slowed because the first otherwise satisfactory hybrids matured too late—not too late to yield well but too late to give the farmer ample time to harvest and replant his land for the following grain crop.

Wide adaptability to variation in day length has recently become an objective of the plant breeder. The hybrid grain sorghums developed in the United States have much wider adaptivity than our hybrid corns. Attempts are beginning to breed corn for nonsensitivity to day length.

### HYBRIDS

Heterosis is the increase in growth-rate, size, yield, and general vigor of hybrids over parents. The use of heterotic hybrids for grain production is a goal of all cereal breeders, more remote for some than for others. In corn, sorghum and pearl millet, this goal has been achieved; hybrids are being used successfully. In the United States hybrid seed corn, the product of crossing inbred (homozygous) lines to produce either single cross, three-way or double cross hybrids, is used to plant almost 100 percent of the acreage. Our sorghum is almost entirely hybrid. Pearl millet is being successfully hybridized in India and elsewhere in the same pattern. The use of hybrid corn and hybrid sorghum outside the United States has increased rapidly in the past two decades. The production of this first generation hybrid wheat is now underway. Whether this venture will become a commercial success may be determined this year. Efforts are being made to develop solutions to the problems of producing hybrid seed of rice, barley, oats and rye on a field scale.

The economic value of heterosis in corn and sorghum has been immense. Yield increases of the order of 20 percent were obtained when hybrids first replaced varieties. Subsequent improvements have given further substantial advances. Single cross hybrids of corn, considered too expensive to produce commercially when hybrids were first introduced, are now taking over an increasing acreage. It is likely that, in consequence of superior performance, they will come to dominate.

The trends in yields of hybrid corn and non-hybrid soybeans in this country in the period 1951 to 1965 show well the overall value of hybridization. A great deal of effort by able plant breeders has been devoted to improvement of soybeans, which do not lend themselves to hybridization. Both corn and soybeans are grown on the same land at different times in a rotation. Corn receives fertilizer because it responds well. Weed control and other cultural practices

are comparable for the two crops. Expressed as kilograms per hectare, corn and soybean yields have increased as follows:

| Years averaged | Corn | Soybeans |
|---|---|---|
| 1931 to 1935 | 1,520 | 1,009 |
| 1941 to 1945 | 2,206 | 1,244 |
| 1951 to 1955 | 2,690 | 1,345 |
| 1961 to 1965 | 4,426 | 1,628 |

Source: U S Department of Agriculture.

The smaller increases in yields of soybeans are due to lack of hybrid vigor and lack of responsiveness to nitrogen fertilization. From 1930 to 1960, corn acreage in the United States decreased approximately 30 per cent while total production increased by nearly 70 per cent. During the last eight years productivity has further increased. The average corn yield per acre in the United States from 1960 to 1964 was 62.4 bushels. In the years 1965 and 1966, averaged, the yield was 72.95 bushels.

The history of corn breeding is full of forgotten efforts. Both Mexico and Brazil started competent corn hybridization programs about the same time as the United States. The efforts failed because they did not receive sustained support. Seed production and distribution in Mexico has been the responsibility of a government agency which has failed to produce either the quantity or quality of seed needed. Government agencies generally make poor seed producers. India is encountering some of these same problems. In Argentina, corn hybrids got a bad name because the first hybrids introduced were neither adapted to the country nor to the grain markets of Buenos Aires. The magic name "hybrid" has been misused in other countries also.

### WORTHWHILE RISK

Yet good hybrids sell themselves wherever they are made available to farmers. Whether the use of first generation hybrids will extend to the small grains—rice, wheat, etc.—is above all a problem of economics. It is a safe bet that a farmer will risk one dollar for the possibility of gaining ten. When he becomes more sure of the gain, he may be willing to risk two dollars to gain ten. U.S. farmers regularly risk two dollars in pesticides for expected or average ten dollar return.

Remarkably, considering the wide use and great economic importance of hybids, the biological basis for hybrid vigor is not well understood. Our present conflicting theories of heterosis were stated more than 50 years ago. The powerful tools of statistical analysis have not, as once hoped, shed much light on this puzzle. Perhaps the tools of biochemistry will prove effective. Certainly we should expand fundamental research into the nature of heterosis and the biology of each important food plant.

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## CAN POLITICS KEEP UP WITH TECHNOLOGY?—FEEDING THE HUNGRY

(By Richard Critchfield)

*(Mr. Critchfield, author of* The Long Charade, *is on leave of absence from the* Washington Star *to write a book on world hunger problems. This article originally appeared in* The New Republic, *October 25, 1969.)*

ROME—"It's new but terriffic," said the enthusiastic young French economist as we sipped *cafe expresso* under Rome's sparkling blue October sky. "In four years, 34 million acres planted in the new seeds in Asia alone. Incredible. Malthus may have been right but the crisis in our time will be social not mass starvation.

"We have been forced to redefine the population problem," his British colleague agreed. "Now we worry more about idle arms than hungry mouths. Our new strategy is to go beyond sheer physical food production to income redistribution and jobs. It could be an agricultural revolution of the same magnitude as transformed Europe at the end of the eighteenth century. But the social disorganization could be so large-scale as to make it impossible to realize the new production possibilities."

As they spoke, one could look down from the roof-top *terrazza* of Mussolini's old colonial ministry, which today houses the Food and Agricultural Organization, directly across the via delle Terme di Caracalla, to that supreme assembly of Roman ruins: Palatine Hill, Circus Maximus, the Coloseum, the Forum. The memories of great men, the echoes of noble speeches, the screams of the martyrs, the final onrush of the barbarians, seem to hang all around them; oddly enough, the FAO, which has just completed, after six years work, a master plan to avert world famine in the 1970s and 1980s, is situated in the very heart of ancient Rome.

The challenge is familiar. Every ten seconds four people die of malnutrition, about 190,000 more join the number of earthlings each day. If the present 1.9 per cent growth rate holds, the global population of 3.4 billion will double by the year 2006.

For years, the FAO's former director general, Binay Ranjan Sen, an ascetic Brahmin from India, kept hammering on these chilling statistics. Sen's message was simple and very pessimistic: mankind was approaching the crisis predicted in 1798 by Malthus, and, with the division of wealth broadly coinciding with the division of color, the rich nations of the West were living uncomfortably close to something like a white man's 1789.

Sen's FAO colleagues today say his dire predictions were politically calculated to transform world attitudes on birth control. Except for Pope Paul, irreverently referred to as "that old man over on the hill" by FAO staffers (the Vatican is only a mile or so down the Tiber), it apparently did. For one, the State Department's Policy Planning Council under Walt Rostow in 1964 submitted a secret study to former President Johnson concluding the Malthusian crisis would hit in the mid-1970s. This, widespread monsoon and crop failures and famine in Bihar in 1965 led to Johnson's "short tether" policy of doling out American food aid only for a few months at a time and tying it to specific action by recipients to curb population and grow more food. A few leaders, such as Egypt's Nasser, balked and received no more grain.

But elsewhere the result was a wholesale shift in investment priorities toward agriculture and adoption of new seeds and methods of cultivation. When favorable rains came in 1966–67 and Asian harvests rose spectacularly, a "green revolution" was hailed and there was talk of a few "miracle" rice and wheat seeds ending world hunger. In actuality, according to the FAO, less than 20 tons of Asia's total annual 250 million ton grain harvest this year comes from the new varieties. Their real importance has been as a catalyst, dramatizing to governments the technological rewards of 25 years of past investment and encouraging much greater spending on agriculture.

For instance, I can remember during the height of India's near-famine four years ago interviewing a young Indian seed technician out on a wheat field at Pusa Agricultural Institute near Delhi. The field was one of the first of ten acres to be sown in all of India with the New Mexican dwarf wheat seed. I was surprised and skeptical when he said, "Fertilizer could solve India's food problem within two years. Irrigation takes time, but with enough nitrogen and these new Mexican seeds, we could lick the food shortage in a hurry." At that time such young technicians were voices in the Indian political wilderness; today they are not. This year a third of India's 34.6 million acres of wheatland is sown in the new varieties; the wheat harvest has risen 51 percent in four years and India now spends 20 percent of its foreign exchange on fertilizer.

The new seeds are largely the product of years of patient research by the Rockefeller and Ford foundations, starting with pioneer research in 1943 by Norman Borlaug, J. George Harrar and other plant breeders in Mexico; they cross-bred Mexican wheat, originally brought from Spain by Cortez, with dwarf strains from Japan, eventually producing a shorter, stockier plant which does not fall over under the weight of its own yield. Similar research followed in the Philippines.

The new seeds have the virtues of the old varieties with higher yields and responsiveness to fertilizer, are easier to harvest, and above all, are nonseasonal. Triple-cropping in the same field every year is now well within the capacity of millions of Asian farmers. The seeds are not hybrid; an FAO technician corrected me on this and described them instead as open pollinated, which means that 20 percent of seeds sown need to be replaced every year or they lose their strength. Indeed, one FAO plant breeder feels strongly there may be real trouble ahead unless older, more primitive strains of wheat and rice are isolated from the new varieties and protected from extinction.

So far the new wheat varieties have had real impact only in India, Pakistan and Mexico, although Egypt has developed its own high-yielding seed and the new Mexican varieties are planted in Afghanistan, Iran, Iraq, Kenya, Nigeria, Syria and Ethiopia. In the Middle East this summer, though, it was still touch and go; new rusts and diseases appeared for the first time.

Rice is in deeper trouble The Philippines is a rice exporter for the first time in history, Ceylon has upped its rice crop 34 percent two years running but monsoon floods in Indonesia, Thailand and East Pakistan have been found to drown the new short-strawed plants, cutting off their air and sunlight.

Both the new rice and wheat varieties face consumer problems; everybody from the Turks to the Filipinos has complained about their taste and texture In India and Pakistan, the new wheat is selling at a 20 percent discount and IR8, the famous first "miracle rice" has been found too gluey and unappetizing by most Southeast Asians, who are rapidly shifting to other still newer varieties. Nevertheless, the new rice is planted over more than 13 million acres or nearly seven percent of South Asia's ricelands and, together with wheat and maize, the new varieties now cover 34 million acres or one-tenth of Asia's grain land and its best and most fertile tenth.

This has transformed—at a very fast pace and very unevenly—the situation in many countries where economic growth has been dismally slow the past 20 years. Since the initial impact is to make rich farmers richer and the poor and landless poorer, the social and political changes of the wheat and rice revolution have already been far-reaching Last January, class war struck Tanjore, in south India's rice bowl, which had done exceptionally well in raising rice yields With more to share, landless tenants began fighting landlords for higher wages

Some FAO economists believe the new seeds figured significantly in the fall of Pakistani President Ayub Khan. West Pakistan has been spectacularly successful with both the new rice and wheat on its largely irrigated lands. Steamy East Pakistan goes 60 percent under water during the monsoon season and the new short-strawed rice went under too. With East Pakistan's economic stagnation more apparent than ever, gangs roamed, killing and looting, the administration virtually collapsed and some prosperous farmers who had done well with the new seeds were condemned by "people's courts" on the old Chinese pattern. Until the army restored order, leftist Bengali parties were calling for a mass uprising and seizure of lands. I heard serious talk from both Indians and Pakistanis at the FAO of the possibility that Pakistan's growing economic disparity might lead to a breakoff of East Pakistan and its formation with India's West Bengal of a new independent, leftist and possibly ungovernable republic.

One gets the feeling of living inside a kaleidoscope that has just been given a tremendous shake. When the familiar pattern of things is so suddenly changed, I suppose it is a common experience not to be able to see any pattern at all for a moment or two afterwards But at the FAO, under the aegis of A. E. Boerma, a jolly, energetic Dutchman who succeeded Sen two years ago, the stocktaking is under way; it is felt patterns are beginning to emerge and that they are not all that discouraging at that. Boerma, a Keynesian agricultural economist, sees the basic cause of the world food problem as poverty and—shades of Daniel P. Moynihan—believes a "jobs and income" strategy will be necessary to solve it

He describes the main obstacle ahead in the wheat and rice revolution as the lack of cash in the pockets of large unemployed masses of the world's people, a lack which translates itself into little effective demand or the markets that would motivate peasant farmers to grow more. "It is an almost perfect vicious circle," he says, "aggravated by a rapid growth in population, which means yet more recruits for the legions of the unemployed." The solution he prescribes is "to increase the purchasing power of the impoverished masses, which means increasing their incomes and giving them productive work. The first priority, if we are going to solve the hunger problem, is to increase the number of wage earners"

Dr. Boerma feels this problem is further compounded by a simultaneous and growing demand by small, newly wealthy minorities in the poor countries for much better food, especially meat, which far outruns production, forces prices upward and puts many protein foods out of the reach of the malnourished masses who really need them.

When Boerma first took over FAO, the *Economist* slyly commented that the world food situation seemed to have changed along with the FAO's director general. This was before the full impact of the agricultural revolution hit Western public opinion early last year. Since then Boerma has undertaken the

first major reorganization in FAO's 25 years, trying to replace dead wood with green and get its vast bureaucracy—2,500 staffers in Rome, another 2,000 administering a $100-million-a-year aid program in the field—to help him rethink the food problem.

To bring things into focus, Boerma has the FAO concentrating its energies in five areas: development of the new wheat and rice varieties, reduction of wastage of foods after harvesting (about 10 percent is now lost), an attack on protein deficiency, making fuller use of rural manpower and promoting agricultural projects that increase foreign exchange earnings.

He also seeks a broader multiple approach to agriculture in most poor countries, with heavier fertilizer investment, more pesticides and irrigation, transport, distribution and storage facilities, more credit and extension services, improved trade and price policies and what he calls a "selective expansion" of farm output closely tied to internal and international demand. It takes the whole package, he feels, to make the agricultural revolution work in any given country.

These ideas are all set forth in the FAO's massive new Indicative World Plan (IWP), which after six years of detailed surveys and compilation, will be presented to the FAO's member nations here in early November and delivered in final form to the second World Food Conference at the Hague next June. The IWP, which aims to "indicate" to poor countries what they should do, is timed to coincide this winter with publication of Sir Robert Jackson's current study on whether the United Nations should take over development as a super multilateral aid agency, the World Bank's study of aid by the Pearson commission and preparations for the world's first international conference on the "resources of the biosphere," coming up the year after next.

Where all this is leading is to a search for an answer to the question Walter Lippmann phrased in his 80th birthday warning that "the number of people who need to be governed and are involved in governing threatens to exceed man's capacity to govern." In Lippmann's words: "This furious multiplication of the masses of mankind coincides with the ever-more-imminent threat that, because we are so ungoverned, we are polluting and destroying the environment in which the human race must live. . . . The supreme question before mankind—to which I shall not live to know the answer—is how men will be able to make themselves willing and able to save themselves."

The IWP, which runs thousands of pages in three volumes the size of Manhattan phone books, ends up with much the same conclusion: "A continuation or acceleration of population growth could well prove Malthus to be right in terms of social turmoil if not immediately in terms of famine or disease."

The problem it starkly sets forth is that if present birthrates of 2.6 percent a year continue in the poor countries until 1985 and economic growth stays at the roughly 2.7 percent present level, food supplies would have to rise 80 percent just to avert famine. It would cost the poor countries in 1985 $26 billion annually to import the food they will need, a clear impossibility since they can barely scrape up $3 billion a year for food imports now. Grain exports to Afro-Asia would have to rise to 90 million tons or alternatively 250 million acres would have to be diverted to wheat and rice from other crops and livestock. While Afro-Asia's cities would grow astronomically, 400 million of the extra 1 billion by 1985 would still be left in an increasingly destitute countryside.

FAO's plan to avoid this bleak future, as the IWP simply puts it, is "to make two blades of grass grow where only one grew before" through fully harnessing the technological revolution to achieve annual growth rates gradually rising from 3.3 percent to 3.9 percent. The price tag for the whole 15 years of the plan—fasten your seat belt—is estimated at $110 billion of which $7 billion a year by 1985 would be required in foreign exchange from the developed countries.

This is somewhat lower than an $8 to $10 billion a year given me by British economist Barbara Ward some months ago. Miss Ward told me she felt the Western nations should start planning now for a development budget for the 1970s. "Their total GNP will grow by at least $60 billion each year. That means they will add $600 billion to their output by the end of the decade at the very minimum. Foreign aid has simply got to go up to the $8 to $10 billion a year class if we want to do it in time."

The IWP's budget is based on the estimate that yearly spending on agriculture in the poor countries must be tripled by 1985; of the money, 12 percent would go for irrigation, 35 percent for equipment and machines (40 percent

imported from the West), 16 percent for livestock and buildings, 4 percent for fishing and 3 percent for forestry. With this input, the FAO experts believe wheat and rice production could achieve needed levels by 1980, allowing diversification and intensified land use, both to meet production objectives and assist in creating jobs. It proposes meeting short-term protein needs through vastly expanded pork and chicken programs and long-term needs through high-yielding pulses and soybeans and much more widespread cattle-breeding, including a shift of all sub-Sahara Africa out of crops and into cattle ranches.

Foreign aid, while seen increasing, is also predicted to change, with grain supplies shipping to high-protein foods and milk, and the major need becoming farm machinery, fertilizer and seed processing plant.

The IWP also makes a plea for a single, international aid-coordinating agency to set goals, prevent duplication, administer technical and financial assistance and work out integrated policies for production, trade and aid. On a short-term basis, Boerma, like the World Bank's Robert McNamara, has taken steps to involve FAO in both more integrated country analysis on all aspects of the economy, not simply agriculture, and in closer coordination of its activities with those of other international agencies; he has just established new departments for closer relations with the World Bank and with private industry.

Largely international administration of aid, in FAO's view, is desirable because of the growing need for a global approach to unemployment, disparities between areas of high and low agricultural potential (like Africa), the heavy economic dependence of many ex-colonial countries such as Cuba or Mauritius on a few export crops of declining value (only timber and beef are seen having a growing market in the West), and to avoid such further pollution of the environment as deforestation or misuse of river headwaters.

Although the IWP is a strictly technical document, the economists who wrote it found it impossible to come up with realistic future projections on agriculture without taking social and political implications into consideration. For instance, there seemed to be a consensus among FAO's policy planners that both Western and Communist ideologies have been somewhat overtaken by the agricultural revolution. The general feeling seemed to be that the allegiance of the poor countries is likely to go to whoever can devise a system that allows the fastest economic growth and that both the West and Communist bloc are starting out with major handicaps.

The West, it was said, is saddled with having left behind in its former colonies a ruling political and intellectual elite educated to preserve colonial interests rather than spark the entrepreneurial spirit among its peasant masses on which success in the agricultural revolution depends. The Western-educated elite, which still controls most of the evil administrations and universities in the poor countries, has proved to be very conservative and has not responded very imaginatively to technological breakthroughs.

This would seem to provide an opening to the Communists, but the FAO officials feel they too have been handicapped by a lack of faith in the transfer of technology without the kind of radical social revolution, agrarian reform and restructuring of a society that would make it virtually impossible to harness the new seeds and methods of cultivation. Russia itself has been forced to play only a marginal role because of its own comparatively backward agricultural technology and its rigidity in trying to transfer its own experience of moving directly into rapid industrialization without first putting food production on a sound basis.

China is another story. The FAO experts feel that should Peking ever offer the Chinese peasantry the material incentives that until now have been anathema to orthodox Maoism, the new seeds would have even more spectacular success in China's great northern wheat belt than in India and West Pakistan. One predicted China could easily have a surplus of millions of tons of wheat to dump on the world market even after feeding her 750 million. Until this happens it is felt the key development in the Communist world is what conclusions are drawn when the new 2.5 million acre irrigation project along the Danube in Eastern Europe is soon planted in the new wheat-varieties.

Virtually very FAO official I interviewed believes some form of social revolution will follow the agricultural revolution in all too many of the poor countries. Since the new seeds tend to raise a peasant family's income 20 to 30 percent, the newly emergent commercial farming class is likely to be conservative and

provide a base for stable government—providing it includes a big enough minority of the population (as it clearly does not in East Bengal).

The roughest policy question faced by FAO has been whether to advise governments to steam right ahead to reach national production goals as fast as possible by helping rich farmers or reduce the risk of violent revolution by trying to spread out its investment among the masses of peasants. The policy that has been adopted is to urge countries to make national food goals their top priority, even if it means dangerously accentuating social inequalities. The reason is obvious: mankind has no time to fool around and worry about political niceties.

As one official said, "We are suddenly faced with a situation in which two-thirds of the world's peasants are beginning to become involved in a market economy after centuries of subsistence farming and marginal cash incomes. The peasants are responding to incentives much more overwhelmingly than anyone foresaw. The revolution is coming so fast and is so unprecedented many governments are having to make successive, difficult adjustments in a very short period of time. It is hard for them because their best people are not in agriculture, they lack money and, most critical, many are lacking in imagination. They do not fully recognize the seeds of change"

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## Agriculture Innovation and Its Implications for Domestic Political Patterns in Southeast Asia

(By Vu Van Thai)

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Only three or four years ago a paper on agricultural innovation in Southeast Asia and its implications for domestic political patterns would have been taken as a piece of utter wishful thinking. Innovation in the field of agriculture has generally been slow to come about the world over. The process which historians describe as "The Agricultural Revolution" in Europe, i.e., the introduction of root crops and clover, was in fact very slow, taking about three hundred years to complete; the early belief that this was a kind of "great leap forward" which was achieved within some thirty years in the beginning of the nineteenth century has by now been dispelled.[1]

As far as the developing world, and particularly Southeast Asia, is concerned, the two decades spanning the years from the end of World War II through 1966 were characterized by an almost generalized lack of progress and of innovation in the field of agriculture. In Asia since World War II agricultural output per capita has remained below the pre-war level. Food output per capita in Asia returned in 1959–60 and 1962–63 to the pre-war level, due largely to the expansion of cultivated areas, but then fell below it as it became more difficult to bring more new land under cultivation.[2] Many observers of the developing world predicted at that time that, in the face of accelerating population growth, lagging food production, and increasing dependence on food aid—while expectations were rising—would cause the Third World to experience serious political instability.

The prevailing pessimism could be illustrated by the following quotation:

> If present trends of population growth and food production continue, in the early 1970's India, Pakistan, and Communist China will be candidates for massive famine.[3]

Thus, had it been written three years ago, my paper should have been entitled "Agricultural Stagnation and its Political Implications."

Now extreme pessimism has quickly given place to a general trend towards optimism bordering sometimes on over-enthusiasm, as people are talking more and more of the "Green Revolution" or of "a new agricultural era" in the tropical world. Lester R. Brown, the administrator of International Agricultural

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[1] See Eric Kerridge, *The Agricultural Revolution*, London 1967, and B. H. Slicher Van Bath, *The Agrarian History of Western Europe A. D. 500–1860*, London 1963.

[2] FAO, *The State of Food and Agriculture*, Roma 1965. Asia is here used as equivalent to the FAO classification "Far East" i.e., Asia excluding Mainland China and the Middle East countries

[3] *Foreign Policy Briefs* by Office of Media Service, Bureau of Public Affairs, Washington, D.C., Vol. XVI, No. 15, January 6, 1967, p. 6.

Development Service, U.S. Department of Agriculture, describes this new era in these terms:

"The new era is characterized by explosive increases in production of principal crops in the larger developing countries of Asia. The 1968 Pakistan wheat harvest was up 37 per cent over the *previous record*, possibly an increase without precedent in any major country. India's wheat crop this year was up 35 per cent over the *previous record;* its total food grain harvest up 12 per cent. Ceylon's rice crop has increased 34 per cent during the past two years. The Philippines with two consecutive dramatic gains in its rice crop, has apparently ended half a century of dependence on rice imports. . . . Increases in per acre wheat yields in Pakistan and India and of rice yields in the Philippines over the past *two years* may exceed those of the preceding *several decades.*

"Thus far the most rapid advances have been concentrated in Asia, a region containing more than half of the world's people. But countries elsewhere—Mexico in Latin America and Kenya and the Ivory Coast in Africa—are also enjoying the fruits of modern technology. Within the next several years the agricultural revolution will likely spread to most of the less developed world.

"The new era is dynamic, providing new opportunities for farm families, promising to bring into the market place literally hundreds of millions who heretofore have eked out a subsistence living, consuming all they produce. This will broaden the market within individual developing countries, greatly enhancing the prospect for industrial development" [4]

But as hopes and expectations are rising there is also a mounting awareness of the long range problems which are cropping up as a result of this breakthrough. In a recent article Clifton R. Wharton, Jr. has very well set the question "The Green Revolution: Cornucopia or Pandora's Box?" [5] He writes in his introduction:

"The application of science and technology to traditional agriculture has begun to produce dramatic results, above all in Asia. The rapid expansion of certain food grains in the developing world is being particularly widely heralded, and justly so, as the 'Green Revolution'. On the one hand, some observers now believe that the race between food and population is over, that the new agricultural technology constitutes a cornucopia for the developing world, and that victory is in sight in the 'War on Hunger'. Others see this development as opening a Pandora's box; its very success will produce a number of new problems which are far more subtle and difficult than those faced during the development of the new technology."

Among the problems that Dr. Wharton has identified and enumerated, the most important in my view is: "What are the political consequences of the green revolution?"

Will rapid agricultural innovation in Southeast Asia bring about political stability or instability? Who, as between Karl Marx and de Tocqueville, will be right in this case? Is revolution the result of growing poverty or growing prosperity? Will those optimists who hold that economic progress will result in greater satisfaction and increased political stability be right in this case or will the "Green Revolution" prove right those who contend that peasants revolt where they are better off?

Recent events in Pakistan are a reminder that economic progress as represented by a high rate of growth without parallel political development might not lead to political stability. In particular, it might be interesting to observe how much the "Green Revolution" in East Pakistan has been correlated with the demands of East Pakistan for a greater say in the administration of its own affairs.

Has the change in attitudes brought about by the "Green Revolution" made farmers more responsive to the nationalist wave in East Pakistan? Has the fact that the development of the high yielding varieties in East Pakistan lagged behind that of the West played any role in arousing popular discontent? Have specific shortcomings in the implementation of the program, such as deficiencies in providing the inputs at the right time and at the right place, or failures in storage, processing, and marketing been among the causes of discontent? In Europe, although as I have pointed out the agricultural revolution did effectively last three centuries, progress in the peasants' standard of living, combined with the changes

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[4] Lester R Brown, *A New Era in World Agriculture*, presented at the first annual Senator Frank Carlson Symposium on World Population and Food Supply, Kansas State University, Dec. 3, 1968.

[5] Clifton R. Wharton, Jr., "The Green Revolution: Cornucopia or Pandora's Box?", *Foreign Affairs*, Vol. 47, No. 3, April, 1969.

in agrarian structure, did play a role in the spread of the revolutionary wave to modernizing rural areas.[6]

More recently again discontent and turmoil, in rural areas of France, were most pronounced in Brittany, where the past decade has brought about a rapid change from a structure of traditional farming to a structure of industrial farming with significant increase in land and labor productivity.

Reviewing theories of revolution, Lawrence Stone writes:

"Fundamental to all analyses, whether by historians like Brinton and Gottschalk or by political scientists like Johnson and Eckstein, is the recognition of a lack of harmony between the social system on the one hand and the political system on the other . . . the dysfunction is the result of some new and developing process, as a result of which certain social subsystems find themselves in a condition of relative deprivation. Rapid economic growth, imperial conquest, new metaphysical beliefs, and important technological changes are the four commonest factors involved, in that order. If the process of change is sufficiently slow and sufficiently moderate, the dysfunction may not rise to dangerous levels . . . . But if the change is both rapid and profound, it may cause the sense of deprivation, alienation, anomie to spread into many sectors of society at once, causing what Johnson calls multiple dysfunction, which may be all but incurable within the existing political system." [7]

One must admit that the "Green Revolution" involves the first and the fourth criteria as ranked by Stone and that the change might be expected to be relatively rapid (at least during the initial phase) and rather profound.

More specifically having in mind the developing countries two economists Arthur Lewis and M. Olson [8] have pointed out that pre-industrial and industrial societies are relatively stable and relatively free from revolutionary disturbances, while in transitional societies modernization causes instability by shifting the relative importance and status of the various classes, thus generating social stresses.

While they implied mainly a process of modernization through industrialization it is interesting to determine what changes in status and in the basic interest of different classes the "Green Revolution" is likely to bring about, and what kind of stresses would result from these changes in the various Asian societies.

As a preliminary, I would stress, among the features of the "Green Revolution", its rapid rate of adoption by the farmers. Wherever a program of introduction of the high yielding varieties has been launched in suitable ecological conditions, its development has been more rapid than the most optimistic initial expectation.

The rate of expansion is indeed explosive as illustrated by the following table:

*Estimated acreage in high yielding varieties in Asia* [9]

| | *Acres* |
|---|---|
| 1964–65 | 200 |
| 1965–66 | 37,000 |
| 1966–67 | 4,800,000 |
| 1967–68 | 20,000,000 |
| 1968–69 (goals) | 34,000,000 |

Although I do not underestimate the effects of the vigorous campaigns launched by the different Asian governments, these are not in my view sufficient to explain the difference in overall behavior of the farmers in this case, when compared with previous unsuccessful attempts to bring about innovation in cultivation techniques.

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[6] See Alexis de Tocqueville, *L'Ancien Regime*, Oxford 1947, and Crane Brinton, *The Anatomy of Revolution*, New York 1965.

[7] Lawrence Stone, "Theories of Revolution", *World Politics*, Vol. XVII, No. 2, January 1966, p 165.

[8] W. Arthur Lewis, *Conference Across A Continent*, Toronto 1963, pp. 46–60, and M. Olson, "Rapid Growth as a Destabilizing Force", *Journal of Economic History*, Vol. XXIII, December 1963, pp. 529–552.

[9] Dana G. Dalrymple, "Estimated Area of High Yielding Varieties of Grains in Ten Asian Nations", International Agricultural Development Service, U.S. Department of Agriculture, November 1968.

In my opinion, the success in the rapid expansion of the high yielding varieties shows that the traditional view attributing a stagnant agriculture in developing countries to the main following reasons:

1. the "absorption capacity" of the farmers is low;
2. the farmers are tradition-bound;
3. and the farmers are illiterate and subject to cultural and institutional restraints, etc.[10]

has to be revised. Restraints of this type do exist and have a retarding influence but their effect has been overestimated. The main reasons for a stagnant agriculture in the past must now be attributed to the fact that there was no new technology available providing investment possibilities with high returns to the farmers. We tended to forget that in rural areas of Asia the existing prevailing rate of interest is usurious, more often than not exceeding 100%. The very favorable response to the new high yielding varieties can be explained only by the fact that these varieties are highly responsive to all factors of production, thus allowing new inputs to yield high returns in the order of doubling or tripling the productivity per acre.

That we have in the past underestimated the rationality of peasant behavior is further corroborated by interviews on the motivation of the farmers for the adoption of the new technology. Examples would be the surveys conducted by IRRI among Filipino farmers, as indicated in Tables 1 and 4.[11]

Those results show that the change to the new technology was for the most part a deliberate well thought out decision based on sound observation of its many shortcomings and its few but essential advantages. External inducement (besides price incentives) played a negligible role. Every indication points out that those so called "unabsorbative, tradition-bound and illiterate" farmers are more economic and business-minded than most of their sophisticated observers would have thought a few years ago. It would be surprising that this awakening of economic consciousness would not extend progressively (or rather quickly) into a social and political awareness.

In my view the emergence of a political force in the rural areas undergoing the "Green Revolution" is all but melictable. The questions are only whether the political institutions of the country will evolve fast enough to allow for the peaceful emergence of this force into the national political fabric, and whether, governments would be able to design and implement policies which would solve or at least keep under control the problems generated by the unfolding of the "Green Revolution". Those problems as enumerated by Clifton Wharton are indeed formidable. Among them I will comment only on those with important political implications and particularly on the gaps which are likely to develop and grow in the social structure of a country, thus generating greater social tensions.

RESULTS OF SURVEYS CONDUCTED BY IRRI AMONG FILIPINO FARMERS

TABLE 1.—REASONS GIVEN FOR THE ADOPTION OF IMPROVED VARIETIES OF RICE, LAGUNA, PHILIPPINES, 1967 WET SEASON

| | Number of farmers giving the reasons | Number of farmers indicating the single most important factor |
|---|---|---|
| a. Expected high yield | 105 | 97 |
| b. Landlord's decision | 55 | 6 |
| c. Follow advice of extension worker | 68 | 0 |
| d. Expected high price | 41 | 1 |
| e. Follow advice of neighbor | 11 | 0 |
| f. Others | 21 | 6 |
| Total | | 110 |
| Total number of adopters | | 110 |
| Total number of responding | | 110 |

[10] Indus Special Study, "Programme for the Development of Irrigation and Agriculture in West Pakistan", May 1966 by Sir Alexander Gibb and Partners, International Land Development Consultants, N.V. Hunting Technical Services Limited, London and Arnhem.

[11] "Agricultural Economics", Research Programme Outline, a publication of IRRI, Los Banos.

TABLE 4.—RELATIVE ADVANTAGES BETWEEN NEW VARIETIES VERSUS LOCAL VARIETIES AS REPORTED BY 153 FARMERS, LAGUNA, PHILIPPINES, 1967 WET SEASON

| Item | Number of farmers reporting | | |
|---|---|---|---|
| | Better | Worse | Same |
| Price | 3 | 148 | 2 |
| Yield | 150 | 2 | 1 |
| Eating quality | 4 | 144 | 5 |
| Disease resistance | 22 | 119 | 12 |
| Lodging | 151 | 2 | 0 |
| Amount of weeding labor requirement | 7 | 120 | 26 |

These gaps are going to be twofold: between rich and poor farmers within areas where water control and existing facilities allow the growing of the high yielding varieties of rice, and between those areas and the other rural areas. Wharton describes these very sharply:

From all this one may deduce that the "first" or "early" adopters of the new technology will be in regions which are already more advanced, literate, responsive and progressive and which have better soil, better water management, closer access to roads and markets—in sum, the wealthier, more modern farmers. For them, it is easier to adopt the new higher-yield varieties since the financial risk is less and they already have better managerial skills. When they do adopt them, the doubling and trebling of yields mean a corresponding increase in their incomes. One indication of this is the large number of new private farm-management consultant firms in the Philippines which are advising large landlords on the use of the new seed varieties and making handsome profits out of their share of the increased output.

As a result of different rates in the diffusion of the new technology, the richer farmers will become richer. In fact, it may be possible that the more progressive farmers will capture food markets previously served by the smaller semi-subsistence producer. In India, only 20 percent of the total area planted to wheat in 1967–68 consisted of the new dwarf wheats, but they contributed 34 percent of the total production. Such a development could well lead to a net reduction in the income of the smaller, poorer and less venturesome farmers. This raises massive problems of welfare and equity. If only a small fraction of the rural population moves into the modern century while the bulk remains behind, or perhaps even goes backward, the situation will be highly explosive. For example, Tanjore district in Madras, India, has been one of the prize areas where the new high-yield varieties have been successfully promoted. Yet one day last December, 43 persons were killed in a clash there between the landlords and their landless workers, who felt that they were not receiving their proper share of the increased prosperity brought by the Green Revolution.[12]

To the consequences listed by Wharton, I would add that in areas where conditions do not at present allow the growing of the high yielding varieties, demands for water control will grow stronger and stronger, and they will be made more and more in the name of social justice. Whatever the amount of resources which could be devoted to these investments, one might foresee that the issue of giving priority to developing one area over another will become increasingly a politically loaded matter.

There is also the danger that because of the spectacular payoff of the high yielding varieties, programs would be conceived exclusively from the point of view of maximizing economic returns to the neglect of social aspects. In my view this will result in growth without development which cannot but engender tensions and instability.

As food production grows and nears the level of self-sufficiency and that of surplus, the problem of misery in the midst of plenty will become more and more acute. Unless countries revise drastically their economic development strategies and policies, to give first priority to the objective of creation of employment; and unless they take measures to reduce income disparities and to further extend incomes to the poorer classes, many people will still go hungry or remain underfed. At the same time such countries will have growing difficulties in exporting limited amounts of surplus in view of the worldwide spread of the "Green Revo-

[12] Clifton Wharton, Jr., *Op. Cit.*, pp. 467–8.

lution". Thus if internal demand is not enlarged, measures to restrict production will have to be adopted. Personally I think that the problem of production and supply and that of effective demand and income could be matched only if an industrial revolution is soon to follow the "Green Revolution." This, among others, implies that the industrialized countries are willing to revise their protective policies to allow for a redistribution of labor—intensifying activites among the developing countries.

What will be the impact of the "Green Revolution" on the relationship between landlords and tenants and on the problem of agrarian reform? As the high yielding varieties increase the tenants' income, one of the few useful functions of the landlord, that of crop financing, is going progressively to disappear, even though initially, because of the cash requirements for the purchase of inputs, farmers might have to rely more on the landlords for the first few years. Another occasional function of the landlord, that of advisor, will also become marginal as the farmer acquires more technical and business know-how with the adoption of the new technology. The revising of the share of the crop, depending on whether the tenant or the landlord finances the cash inputs, cannot but increase tensions. Finally, as returns increase and cultivation becomes more profitable, there will be a tendency among landlords to recover for themselves at least part of their lands for direct cultivation with mechanized equipment and/or hired labor.

As in most instances the rent is based on a fixed percentage of the crop, the absolute price of the rent will increase as yields increase, and tenants will find more and more that they are paying too much to their landlords.

Thus it is safe to assume that the "Green Revolution" is likely to increase tensions between landlords and tenants on the other hand as returns increase, pressure on the part of tenants for greater agrarian reform will mount, while vested interests to oppose it also increase as ownership of land becomes more profitable

Besides the tensions and instability resulting from the process of modernization discussed above, I would like also to draw attention on the possible political effect of the momentum of the "Green Revolution" itself. According to James C. Davis,[13] rapid economic growth produces stresses but so long as the standard of living is growing relatively fast enough to keep pace with existing expectations, social stresses are not likely to lead to disturbances. The moment of potential revolution is reached when growth lags behind expectations, i.e., when a phase of growth is tapering off and some stagnation or decline is taking place. Indeed, as Wharton has suggested, one might expect that the spread of the new technology will slow down after the initial explosive take-off: first, once all existing irrigated lands have been converted to the new varieties; and, secondly, when the easily irrigable potential has been exhausted Another potential bottleneck likely to slow down the rate of expansion is the capacity of supporting facilities in the field of transport, processing and marketing.

Finally, with respect to economic growth and income, one might expect at some stage that the increase in productivity will be offset by the decline in price or at least in farmers' return, and this mostly for two reasons: first, that production might grow faster than demand while export prospects will decline, thus depressing prices; and, secondly, because governments will tend in the initial phase to encourage production through a policy of favorable price of rice or of subsidy to lower the loss of inputs. But, as the program becomes larger and larger, these cannot be maintained indefinitely.

In fact, the problem goes deeper and we are facing a kind of vicious dilemma: in order to keep demand up to the level of increased agricultural production, a government must either accelerate considerably the rate of growth of the economy or else embark on large expenditures for welfare. To do either of these, it must mobilize more and more resources from the agricultural sector; by so doing it is slowing down the rate of increase of farmers real income, thus triggering discontent.

All the above might appear overly pessimistic. It would have been far more comfortable to discard all the obstacles ahead with the simple notion that more material wealth and more food is tantamount to economic growth will result in orderly social and political development. This would be, in my view, unrealistic and dangerous. We had better face clearly the obstacles ahead rather than adopting the position of the ostrich.

Does this mean that we have to slow down and keep the pace of the "'Green Revolution" under prudent control? I do not think so. First, even if we wanted

[13] James C. Davis, "Towards a Theory of Revolution", *American Sociological Review*, Vol. XVII, February 1962.

to. by now hopes and expectations aroused by the first spectacular results of "Miracle Rice" are such that no political leader can slow down today's momentum without risking serious trouble Second, both on moral grounds and by necessity, we have to win the race between food production and population increase. And, like Wharton, I believe that the "Green Revolution" will allow us only to earn a brief respite in this anguishing race, during which we will have to learn to curb the world population explosion. Third, realistically we should expect turmoil and instability to stay with the Third World, whether it is stagnant or developing until it has accomplished the most essential parts of its process of modernization.

I disagree with the view that a 20th century pre-industrial society, if exposed to technology and submitted to the products and the policies of industrialized societies, can be a stable society. The history of the Third World, all over Asia, Africa and Latin America, since the end of World War II, when there was neither a "Green" nor an "Industrial" Revolution, was rather formented Political instability was the rule rather than the exception. My own conviction is that political instability resulting from innovation and modernization will be no greater than the one created by stagnation and frustration in the past.

But whatever the degree of turmoil ahead of us, it is in my view very important to observe that violence and instability in a situation of stagnation are more likely to result in a *repression* of the process of modernization of political institutions; while when this happens as a result of rapid growth, the chances are enhanced that the final result would be some *progress* in the modernization of the political structure of the country.

In a situation of stagnation and underdevelopment, when the attitudes of broad categories of the population are still inactive, a change of government through the breaking of law and order could only result from the competition for a greater share of Power between the small privileged classes: the military, the politicians, the bureaucrats, the landlords, the merchants and the intellectual elite. This kind of violent competition leads only to the narrowing of the control of Power into fewer categories of the above mentioned privileged classes (in most instances, the military). Thus the end result is most likely to be an accentuation of the feudal character of government. Whether good or bad this change represents a regression in the process of political modernization. In a few instances, those of the privileged clases frustrated by their elimination from Power might attempt to appeal to the most discontented elements of the destitute masses in order to launch a guerrilla warfare. This might bring about a long process of endemic violence with a possible final phase of generalized guerrilla warfare. Even if a more popularly based regime is to emerge in the final end it is most likely to be ruthless and in my view this is also a regression in the process of political maturation.

In contrast to the cases envisaged above, if violence is to erupt in a country where the "Green Revolution" is taking place, whatever the initial cause, it is likely to involve the larger groups which have been awakened by the "Green Revolution", or even the broader masses of those to whom the fruits of this technological advance have been denied. The end result of this kind of upheaval is most likely to be either new political institutions allowing for greater participation of the awakened rural classes or else the emergence of enlightened leadership with policies which will satisfy the aspirations of these groups.

The reasons why I believe that the degree of instability and violence brought about by the "Green Revolution" might be limited is that, as Stone points out:[14]

Revolution is never inevitable—or rather the only evidence of its inevitability is that it actually happens. Consequently the only way to prove this point is to indulge in just the kind of hypothetical argument that historians prudently try to avoid. But it is still just possible that modernization may take place in Morocco and India without revolution. The modernization and industrialization of Germany and Britain took place without revolution in the nineteenth century (though it can be argued that the latter case was slow by twentieth-century standards, and that, as is now becoming all to apparent, the modernization was far from complete). Some think that a potentially revolutionary situation in the United States in the 1930's was avoided by political action.

Furthermore, as Eckstein[15] rightly stresses, in addition to the factors of rapid social changes discussed above one must consider a second vital element of great importance in the development of a revolutionary situation: that is, the

[14] Lawrence Stone, *Op. Cit.*, p 166.
[15] Harry Eckstein, "Internal War" New York, 1964, and "On the Etiology of Internal War."

condition and attitude of the entrenched elite. The elite may lose its manipulative skill, or its military superiority, or its self-confidence; it may be incompetent, or weak, or brutal. A combination of two or more of these features might lead the elite to the fatal course of compounding its errors by intransigence. If the elite fails to anticipate the need for reform, if it blocks all peaceful, constitutional means of social adjustment, then it unites all the discontented elements into violent opposition. But if it rises to the challenge, violence might be avoided. In fact in Asia, except for Japan, we have now the example of two countries experiencing rapid economic growth with parallel modernization of their rural areas: South Korea and Nationalist China without being subject to political turmoil, at least up to this stage.

In Nationalist China the arbitrariness of the regime has been greatly reduced by the emergence of a new elite of technocrats whose share in policy formulation has been increasing with economic success. Since their weight in the power structure depends more on their professional ability than on vested interests, the style of the government has become more and more one of service to the people.

In Korea the evolution was twofold: there were both the emergence of a group of professional bureaucrats and the development of political institutions allowing for greater popular participation. It is significant that during the last presidential election, President Park's platform was focused mainly on the Economic Development Plan. In both countries an effective agrarian reform program had been undertaken.

In my opinion one of the best guarantees for a peaceful political development would be the leaders' awareness of the political potential of the "Green Revolution" and their readiness to ride on the wave of this Revolution. I have found for instance that the fact that President Marcos made of the "Miracle Rice" a political issue on which he would stake his political fortune, has on one hand given a strategic impetus to public and private efforts to expand the new technology and tackle the problems arising from its development; on the other hand this has enormously uplifted the political status of the long-neglected peasantry. Reading Dr. Gelia Castillo's delicious account of "Miracle Rice" as "produced" by the Filipino press[16], I have the impression that "Miracle Rice" has produced another miracle, for never has the press of any developing country devoted so many of its columns with such passion to the problems and the lot of its rural population. May this be the first step in bridging the much publicized "gap" between the cities and the countryside.

I am myself confident that most leaders with a progressive or an open-minded, moderate attitude will rise to the challenge and the opportunities of the "Green Revolution". As for those too conservative to readjust to the pressures of modernization of the rural areas, too authoritarian to allow for the emergence of a new elite more closely related to the expectations of the masses, they will be swept away by the wave of change.

Asia cannot afford to miss the opportunities of the "Green Revolution" to modernize its political institutions and bring about broader participation of its rural population in the political process. Even if this is at the cost of violence erupting here and there, this will be a moderate price. After all the industrialized countries paid a high price of revolutions and wars for their process of political modernization.

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## The Seed-Fertilizer Revolution and Labor Force Absorption

By Bruce F. Johnston and John Cownie

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[16] Gelia Tagumpay Castillo, "'Miracle Rice' as 'Produced' by the Press" a paper prepared for the International Seminar on Communications Media and National Development, University of the Philippines, Diliman, Quezon City November 1963.

*ever, are to the late Ghulam Mohammad whose unusually perceptive analyses first directed his attention toward West Pakistan's agriculture and to E. H. Clark, II, his successor as head of the agriculture division of the Pakistan Institute of Development Economics. This article originally appeared in* The American Economic Review, *Volume LIX, No. 4:1, September, 1969.)*

The high yielding varieties of rice and wheat that are currently having such a dramatic impact on agricultural output in a number of developing countries underscore the importance of production function shifts as a key element in strategies for agricultural development. Studies of the historical experience of Japan and Taiwan in particular have stressed the role of technical change in enabling agriculture to make a significant contribution to development. Technologically induced increases in the productivity of the existing on-farm resources of labor and land made possible growth in farm output at rates that greatly exceeded the associated increases in inputs [4] [13] [17] [24]. These gains (in agricultural productivity) were of decisive importance in meeting the food requirements of expanding populations and in enlarging foreign exchange earnings. They also made possible the simultaneous growth of industry and agriculture, with the more rapid expansion of the nonfarm sectors leading to the transformation of the overwhelmingly agrarian structure of the economies.

Currently there is increasing awareness of the employment implications of alternative development strategies. The population explosion, increasingly conspicuous in the underdeveloped world since the 1950's, is being followed by a labor force explosion that will manifest itself fully by the 1970's. Economists concerned with the employment implications of a rapidly growing labor force in economies already characterized by underemployment and unemployment have often recommended wage subsidies to accelerate the growth of employment [18]. A program of wage subsidies cum profit taxation poses difficult administrative problems, however, and may have other disadvantages [30]. Furthermore, in many developing countries some 60 to 80 percent of the labor force is still employed in agriculture; and with rapid growth of the total labor force, the number of workers in agriculture will continue to increase for decades and even the decline in the relative size of the agricultural labor force will be slow [15, pp. 267–75]. Therefore, the most important single factor influencing a developing country's ability to absorb a growing labor force into productive employment is the type of strategy pursued for developing its agricultural sector.

## I. THE SEED-FERTILIZER REVOLUTION

The labor-using, capital-saving type of approach to agricultural development pursued in Japan and Taiwan recommends itself because of its implications for the growth of employment opportunities both in agriculture and in the nonfarm sector. Until recently the possibility of pursuing similarly labor-intensive strategies of agricultural development in the contemporary underdeveloped countries rested very much on an article of faith; it seemed reasonable to infer that the cumulative progress in agricultural science and in research techniques in the developed countries could generate technical innovations adapted to the physical, economic, and socio-cultural conditions of other countries. That theoretical possibility has now become a reality for the increasing number of less developed countries in which new high yielding, fertilizer-responsive varieties are being introduced, and where the use of chemical fertilizers is expanding rapidly.

West Pakistan in particular is in the midst of changes taking place at a truly revolutionary pace. Between 1965–66 and 1967–68, the area planted to the Mexican dwarf varieties of wheat increased from 12 thousand acres to an estimated 2.5 to 3 million acres [6] [22]. The rate of spread for IR–8, the first of the dwarf varieties of rice to be released by the International Rice Research Institute in the Philippines, has been even more spectacular. Since seed requirements are unusually small for rice, the harvest from but nine thousand acres planted to IR–8 in the summer of 1967 provided the seed in 1968 for close to 900 thousand acres, more than 25 percent of the total rice acreage in West Pakistan [1] [7].

In the Indian Punjab, the spread of high yielding wheat varieties and the rate of increase in fertilizer use appears to have been about as rapid as in the Pakistani Punjab, and the new varieties are also beginning to have a significant effect on production in a number of other Asian and Middle Eastern countries. Similarly, the new varieties of rice are already having a notable effect on production

in the Philippines, Malaysia, India, Indonesia, and trial plantings in Africa and in Latin America have shown great promise.

In spite of the fact that these developments are so recent, it seems possible to present some important conclusions, which, even two or three years ago, could only have been advanced as optimistic hypotheses.

(1) The new dwarf varieties of rice and wheat developed for tropical and sub-tropical regions can be expected to give a greater yield response per pound of fertilizer. Even more important, the "architecture" of these short, stiff-strawed varieties permits them to maintain highly favorable response ratios up to levels of fertilizer application three or four times as high as the level at which traditional varieties begin to show a decrease in yield. Potential yield increases are of the order of 50 to 200 percent or more if the introduction of the dwarf varieties is accompanied by higher levels of fertilizer application and certain other changes in farm practices.

Possibilities exist in a still wider range of agro-climatic conditions for similar yield increases based on the introduction of high yielding varieties of maize, which ranks next to rice and wheat as a dominant staple food To cite two African examples, notable results have already been achieved among smallholders in Kenya and Zambia. The immediate prospects for the other major grain crops are less promising, although India is achieving noteworthy results with millet hybrids, and high yielding sorghum varieties have been developed in a number of countries.

(2) The success of the geneticists and plant breeders in developing varieties of wheat and rice that are not sensitive to differences in day length, and which have built-in adaptability to a wide range of environmental conditions, has greatly increased the possibility for international transfers of high yielding varieties. This has reduced the time required for adaptive research and trials in specific new localities. There is still a great need, however, to develop rice varieties more resistant to diseases and pests and better suited to the taste preferences of local rice consumers. For wheat, the greatest need is for a continuing breeding program in each area to permit varietal changes as certain varieties become vulnerable to the present or new races of rust.

(3) Progress in fertilizer manufacturing techniques and in mining technologies can be expected to enhance the profitability of new seed-fertilizer combinations. Cost reductions and declining real prices have contributed importantly to the enormous postwar increase in fertilizer production and consumption from 9.7 million nutrient tons in 1946–47 to 46.3 million tons in 1965–66 [32, pp. 134–35] [28]. Further highly significant cost reductions and large increases in fertilizer production that are now in prospect will have their major impact on the underdeveloped countries where consumption is already beginning to show a rapid increase—from 2.3 to 6.7 million tons between 1955–56 and 1965–66. The prospective increases in capacity and output are especially important for nitrogen; the capital cost of the large scale plants under construction or recently completed is nearly 50 percent less than for plants with "the old pre-1963 technology" [8, pp. 6–7]. It is estimated that world productive capacity for nitrogen fertilizer will increase by more than 100 percent between 1966 and 1971, potash capacity by 80 percent, and phosphate capacity by more than 50 percent.

## II. THE QUANTITATIVE IMPACT OF THE SEED-FERTILIZER REVOLUTION: WEST PAKISTAN AS AN ILLUSTRATIVE CASE

The determinants of the level of crop production are so complex that a large degree of uncertainty with respect to future increases in output is inevitable. Output depends not only on the levels of resource use, but also on the ways in which farmers use their managerial ability, knowledge, and technical skill in response to the incentives that confront them. It is necessary to consider at least five variables in addition to the variety planted and the level of application of chemical fertilizers and other current inputs:

(1) human labor, considering both the stock represented by the farm labor force and the flow of labor inputs;

(2) nonhuman power inputs;

(3) the quantity and quality of land inputs as determined by the total cultivated area and the cropping intensity;

(4) water availability, with attention to timing as well as quantity; and

(5) farming practices.

The present authors and Bart Duff have made a preliminary attempt to quantify the potential impact of the new varieties on agricultural output in West

Pakistan, using a simple physical projection model for wheat and rice, the two major food-grains in this region of some 55 million persons [5]. The physical environment in the predominantly irrigated agriculture of the Province provides a relatively homogeneous and highly favorable environment for widespread introduction of the new varieties of wheat and rice and for associated increases in fertilizer consumption. Moreover, programs under way or definitely in prospect, such as the Tarbela Dam and the continued expansion of tubewells, will result in a substantial increase in the supply of irrigation water during the Perspective Plan period ending in 1985. Hence it is reasonable to assume that water will be available to permit some increase in cropping intensity and the moderate increases in application of irrigation water required to exploit high rates of fertilizer application.

TABLE 1.—ALTERNATIVE PROJECTIONS OF GROSS OUTPUT OF FOOD GRAINS IN WEST PAKISTAN [1]

[Millions of long tons; rice figures are for clean rice]

| Year | A | | | | B | |
|---|---|---|---|---|---|---|
| | Low | | High | | | |
| | Wheat | Rice | Wheat | Rice | Wheat | Rice |
| 1964–65 | 4.2 | 1.3 | 4.2 | 1.3 | 4 2 | 1.3 |
| 1969–70 | 6.1 | 2 0 | 7.1 | 2.3 | 7.1 | 2.3 |
| 1974–75 | 9.3 | 3.2 | 11.2 | 4.2 | 11.6 | 4.3 |
| 1979–80 | 13.0 | 4.9 | 14.3 | 5.5 | 15 1 | 5 8 |
| 1984–85 | 15.9 | 6 2 | 18.2 | 7.3 | 19 7 | 8 0 |

[1] The underlying assumptions are discussed in [5].

The projection model was used to estimate a set of alternative expansion paths based on various assumptions with respect to the rate of spread of the new varieties, the rate of increase in use of fertilizers, and grain-fertilizer response coefficients. The low and high expansion paths shown in Table 1 heading A are, respectively, moderately and highly optimistic projections of the output increases obtainable within the framework of a bullock-powered agriculture. The high projection takes a more optimistic view of the rate at which farmers will respond to the availability of the new varieties, and it assumes a greater increase in the area planted to wheat and rice. The latter feature is related to a mechanization alternative that assumes a more rapid spread of improved bullock equipment than the low situation and a moderately rapid (5 percent per year) increase in the number of tractors employed. The B alternative in Table 1 assumes that rapid spread of the new varieties would be associated with very rapid tractor mechanization, a 15 percent annual increase, or about the rate recommended to the West Pakistan government in a recent report by a Ford Foundation consultant on mechanization [11].

All of the alternatives are related to the assumption that the farm labor force will increase by about 42 percent between 1968 and 1985.[1] This estimate is based on a projection of population growth by age group, the 1961 labor force participation rate, and the optimistic assumption that nonfarm employment will continue to expand at the 4.5 percent rate registered between 1951 and 1961 [2, p. 71] [3, p 393]. Previous historical experience and recent developments in West Pakistan suggest that an increase in multiple cropping may lead to an increase in farm labor inputs that is considerably greater than the increase in the farm labor force. In Taiwan, for example, an increase in cropping intensity, made possible by increased availability of controlled water supplies, led to a sizable increase in farm labor inputs because of an increase in the average number of working days per member of the farm labor force [17, pp. 93, 99].[2] Ghulam Mohammad's survey of tubewell and nontubewell farmers in West Pakistan indicated that the increase in cropping intensity among tubewell farmers was associ-

[1] Given the rapid growth of the total labor force that is in prospect and agriculture's initial share in the total, the actual increase may well be larger. For a discussion of the evidence that suggests that 4.5 percent represents a "high" rate of growth of nonfarm employment and of the rationale for estimating the change in the farm labor force as a "residual," see [15, pp. 267–75].

[2] Although conditions in Taiwan were not identical to those in West Pakistan, it is pertinent that the notable increase in multiple cropping in Taiwan was achieved mainly with the use of improved bullock-drawn implements. Even now power tillers are used on only about 15 percent of the cultivated area [12].

ated with a substantial increase in the rate of utilization of the existing farm labor force and bullock power [19].

The assumed increases in area planted to wheat and rice for the low alternative in Table 1 heading A are only about half as large as under the B expansion path. The moderate increase in cropped area under the low path should be feasible, provided that improved bullock-drawn equipment and other inexpensive items such as simple rotary threshers supplement the expected increase in the number of farm workers and increased rates of utilization of the labor force and bullock power. Rapid tractor mechanization as under the B alternative would obviously permit more rapid expansion of multiple cropping (provided that water availability is not the limiting factor).

Despite their limitations, the present projections are believed to give plausible indications of the potential capacity of West Pakistan to expand output of wheat and rice Whether such expansion will be desirable is a crucial question that is not answered by our physical projection model. There can be no doubt about the profitability of greatly increased applications of chemical fertilizers unless there is a marked deterioration in grain/fertilizer price ratios. However, no attempt has been made to assess the influence of future demand on the prices of wheat, rice, and competing crops, or to consider other factors influencing relative profitability. It is noted later that export demand conditions will be critical in determining the economic feasibility of the projected increases in output and in dictating the choice of appropriate agricultural development policies in West Pakistan.

## III. POLICY IMPLICATIONS OF THE SEED-FERTILIZER REVOLUTION

The drastic change in production possibilities resulting from the new seed-fertilizer combinations has led to contradictory conclusions with respect to its policy implications. In particular, it has encouraged sharply divergent views concerning the choice between an agricultural development strategy that emphasizes increasing productivity within the framework of the existing small-scale agriculture, and an approach that would give special encouragement to large scale units and an early shift from animal draft power to tractor mechanization.

It is argued here that the existence of yield-increasing innovations which are neutral to scale and consistent with the existing systems of small scale agriculture increases the advantages of the labor-intensive, capital-saving alternative. The essence of this approach (characterized elsewhere as the "Japanese model" in contrast to the "Mexican model" to be discussed shortly) is agricultural development which preserves a unimodal distribution of farm sizes [15]. Wield-increasing innovations and expanded use of fertilizer and other current inputs are diffused widely through the agricultural sector, although there will naturally be variations in the pace and efficiency of implementation associated with differences among farmers in their competence and resources In general, there seems to be a growing recognition of the relevance of this type of approach to developing countries not only in Asia but in parts of Africa and Latin America as well.[3]

Others, however, have drawn very different conclusions from the initial successes of the seed-fertilizer revolution In their view, the introduction of improved varieties should be accompanied by the rapid expansion of mechanization and the replacement of animal draft power by tractors and tractor-drawn equipment. In West Pakistan, for example, many agricultural leaders and development economists are declaring that "the bullock is obsolete." Although it is obviously not admitted, prescribing all-out tractor mechanization under these conditions is equivalent to advocating development according to the "Mexican model," i.e., a farm economy characterized by a dual-size structure with increases in output and commercial sales concentrated in a small subsector of large scale, capital-intensive farm operators.

Such views take on considerable importance because there is a strong likelihood that the seed-fertilizer revolution will give an impetus to premature tractor mechanization. The rapid initial increase in cash income, especially in Pakistan, India, and other countries where rapid import substitution is taking place, increases the ability and the incentive to invest in such equipment. In economies

[3] In a paper that is of considerable interest because of its perceptive analysis of the importance of training programs and development of the managerial skills of farmers, Jon Moris notes that the agricultural strategy that ". . . appears to be the emerging type in East Africa . . . is the pattern which Japan followed historically" [20, p. 323].

in which little structural transformation has occurred and the absolute size of the farm labor force is increasing rapidly, investment in tractor mechanization is likely to be uneconomic from society's point of view even though it is profitable to the large farm operators Their saving in labor costs as determined by market wage rates is likely to be considerably higher than the marginal productivity of the labor that is displaced. The social costs of exacerbating problems of underemployment and unemployment do not enter into their assessment of costs and returns. Moreover, this general tendency for the private marginal productivity of investment in labor-displacing mechanization to exceed the social marginal productivity is frequently strengthened by policies that distort the prices of productive inputs and accentuate the discrepancy between private and social returns. In a number of countries, a sharply differentiated tariff structure with low or zero import duties on tractors, often associated with overvalued exchange rates and programs of subsidized government credit, alters relative factor prices and encourages tractor mechanization.

Explicit attention to the interdependencies between the farm and nonfarm sectors of a developing economy is especially important in throwing light on the complex but critical problem of determining efficient sequences in the modernization of agriculture. Three aspects of these interrelationships merit particular attention: (1) the size and rates of growth of population and labor force in agriculture and the rest of the economy; (2) the interdependence between farm cash income and the use of purchased inputs; and (3) the impact on overall economic growth of alternative strategies for agricultural development.

(1) *Interrelations between growth of population and labor force and agricultural development strategy*

The contrast between East and West Pakistan in the extent to which structural change has led to a decline in agriculture's share of the total labor force, more or less brackets the prospects facing many of the developing countries. In West Pakistan, phenomenally rapid expansion of non-agricultural investment and output between 1951 and 1961 was associated with rapid growth in nonfarm employment, and the share of agriculture in the total labor force declined from 65 to 59 percent [3, p. 385]. Nonfarm employment increased at a rate of about 4 5 percent per annum, a rate which, in the post World War II period, appears to have been exceeded only by Taiwan [15, p. 274]. It is quite possible that increases in the capital intensity of investment and in industrial productivity have meant a slowing of the rate of expansion of nonfarm employment. Data are not available for testing that supposition, but even if we assume that nonfarm employment in West Pakistan will continue to grow at 4 5 percent until 1985, the farm labor force would still register an increase from 7.4 million to 12 2 million. In East Pakistan, where Partition adversely affected economic expansion, nonfarm employment grew so slowly between 1951 and 1961 that agriculture still represented 85 percent of the labor force in the latter year. Even with substantial acceleration in the growth of nonfarm employment, the rapid increase in the farm labor force that is in prospect will give rise to severe problems in East Pakistan where farm units are already excessively small.

(2) *Interdependence between farm cash income and the use of purchased inputs*

The level of farm cash income sets an upper limit on the agricultural sector's purchases of off-farm inputs, although the time pattern of this constraint can, of course, be modified by credit programs. Thus if the commercial market for farm products is small relative to the number of farm households, the use of purchased inputs by the average farm unit is necessarily limited. If the agricultural sector is to maximize output, cash income allocated to the purchase of inputs should be spent mainly on current inputs such as seed, fertilizers, and insecticides; they have highly favorable benefit/cost ratios, and they are complementary to the relatively abundant farm-supplied inputs of labor and land. If agricultural development proceeds along the lines of the "Mexican model," it is possible for a relatively small group of large scale farmers to employ capital-intensive methods. But the establishment of a subsector of large scale units that could satisfy a major part of the commercial demand would mean that the average size of the remaining farm units and their ability to command purchased inputs would be reduced accordingly.

It is the inherent limitations on the size of the domestic commercial market when little structural transformation has occurred which accounts for the fact that agricultural exports represent the major source of farm cash income in many under-developed countries Where scope exists for import substitution or

for substantial expansion of exports, the growth of farm cash income does not depend so heavily on the transformation of the domestic economy. In countries such as India and Pakistan that have been covering food deficits by sizable imports (especially P.L. 480 shipments from the U.S.), import substitution offers the possibility of a rapid rise in domestic farm incomes until self-sufficiency is reached. The possibilities of import substitution in West Pakistan will, however, soon be exhausted, and the only circumstance that would make it economically feasible to exploit the full potential of the new varieties of wheat and rice during the Perspective Plan period would be a world market situation that permitted a huge expansion of exports of these commodities. Clearly, the critical question is whether the increase in effective demand for agricultural products will be sufficient to justify large investments in mechanization to achieve a rate of growth of output even more rapid than that obtainable by the widespread introduction of yield-increasing innovations within a bullock-powered agriculture.

TABLE 2.—FOODGRAINS IN WEST PAKISTAN: SUPPLY AND DOMESTIC DEMAND[1]

[Millions of long tons]

| Year | Wheat | | Rice | |
|---|---|---|---|---|
| | Low A supply | Projected demand | Low A supply | Projected demand |
| 1964–65 | 4.2 | 4 8 | 1.3 | 1.0 |
| 1969–70 | 6.1 | 5.8 | 2.0 | 1.2 |
| 1974–75 | 9.3 | 7.2 | 3 2 | 1.5 |
| 1979–80 | 13.0 | 8.6 | 4.9 | 1.8 |
| 1984–85 | 15 9 | 10.3 | 6.2 | 2.1 |

[1] Output projections from table 1. Growth of demand at 4.1 percent per year is assumed through 1970–71. Annual growth rate then tapers off to 3.5 percent by 1984–85. See [5].

Prospective increases in domestic consumption of wheat and rice in West Pakistan are compared in Table 2 with the projected increases in output under the low A assumptions of Table 1. To the extent that the projections are reasonable, a rather startling conclusion emerges. Recommendations for rapid tractor mechanization imply that 1984/85 goals of exporting 5.6 million tons of wheat and 4.1 million tons of rice are too modest. Clearly, one must accept a highly optimistic assessment of Pakistan's foodgrain export prospects to argue that the large outlays for current inputs associated with all the expansion paths should be augmented by the heavy outlays of capital and foreign exchange to realize the even larger exports that could be attained with the B alternative of Table 1.

Against a background of concern with India's acute food shortages in 1965–66 and 1966–67 and predictions of an impending world food crisis, it is not surprising that the effect of demand limitations on the growth of agricultural output have received little attention. There is, however, an urgent need for revised world projections of import demands and exportable surpluses that take account of the magnitude of the potential impact of the seed-fertilizer revolution. Indeed, in the projections currently available, West Pakistan itself is included among the underdeveloped countries expected to be faced with growing food deficits [31] [33].

In spite of the great uncertainty concerning future export demand and prices, it is no doubt wise for developing countries with a potential for low-cost expansion of grain exports to exploit this opportunity to enlarge their foreign exchange earnings so long as exports are reasonably remunerative. Choice of measures to achieve expanded grain production should, however, take account of the strong possibility that foodgrain import demand may recede in the next decade or two, and that export prices may fall sharply from recent levels. Given this uncertainty with respect to grain export prospects, the presumption is strong that the returns to investing capital and foreign exchange in rapid mechanization would be less than the returns obtainable from alternative uses of these resources.[4]

[4] Important policy issues not examined here include that of determining the optimal product mix in agriculture, given the potential for increased output made possible by the new production functions. Major attention needs to be given to the possibility that an optimal expansion path would involve a shift away from the present heavy emphasis on cereal crops toward products (livestock, vegetables, fruit) with higher income elasticities of demand and the potential to upgrade the quality of Pakistani diets.

The case for rapid tractor mechanization in Pakistan is not conclusive even if one accepts a highly favorable assessment of future demand conditions. An increase in the use of tractors by the larger land owners at the rate consistent with the B alternative of Table 1 would mean that many tenants would be displaced. The opportunities for employment in the large scale, capital-intensive subsector of agriculture would be limited because commercial farmers cannot be expected to employ workers beyond the point where their marginal productivity is equal to the wage rate. Most of the expected increase in the farm labor force would presumably have to be absorbed by the small scale, bullock-oriented subsector where family members join the labor force even though their marginal product may be less than the average product that they consume. Because of the sizable increase in the tractor-commanded area, a substantially increased labor force in this self-employment subsector would be concentrated on a reduced farming area. Such a situation, shown hypothetically in Table 3 on the basis of the B expansion path of Table 1, would involve social costs that might well make this option undesirable even if export demand prospects made it economically attractive.

TABLE 3—POLARIZATION OF WEST PAKISTAN'S AGRICULTURAL LABOR FORCE CAUSED BY A STRATEGY OF AGRICULTURAL DEVELOPMENT EMPLOYING AN ASSUMED 15 PERCENT ANNUAL INCREASE IN TRACTOR UNITS[1]

| Year | Total farm labor force (millions) | Labor employed on tractor units (millions) | Labor employed on bullock units (millions) | Tractor-commanded acres (millions) | Bullock-commanded acres (millions) | Land/labor ratio on bullock units (acres/man) | Percent of farm labor force on tractor units |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1965 | 8.205 | .084 | 8.121 | 1.050 | 33 039 | 4 068 | 1.02 |
| 1970 | 9.026 | 169 | 8.857 | 2.112 | 34.135 | 3.854 | 1 87 |
| 1975 | 9.987 | .340 | 9 647 | 4.248 | 35 743 | 3.705 | 3 40 |
| 1980 | 11 120 | .684 | 10.436 | 8.544 | 35 376 | 3.424 | 6 15 |
| 1985 | 12.249 | 1 375 | 10.874 | 17.185 | 32.004 | 2.943 | 11.22 |

[1] Assumptions The labor force on tractor units shown in col. (2) is estimated at 8 men per 100 acres using the acreage figures in col. (4). Bullock-commanded acres consist of those utilizing improved and traditional cultural practices and equipment. Labor force estimates based on Bose [3] Land area based on the projection under alternative B, table 1.
The size of the total farm labor force is assumed to be the same in all 3 alternatives since it is computed as a residual on the basis of the estimated growth of the total labor force and an annual increase of nonfarm employment of 4 5 percent The figures in col. (3) above, labor employed on bullock units, are also computed as a residual by subtracting col. (2) from col. (1).

### (3) *Agricultural development strategies and their impact on overall economic growth*

Choice of an efficient strategy for agricultural development will affect the process of structural transformation and overall economic growth in two important ways. The impact of agricultural development on the expansion of local manufacturing industries will depend on the composition of farm demand for manufactured inputs and consumer's goods, and on the extent to which this demand is satisfied by domestic production. In addition, the degree to which the agricultural sector can be expected to make a net contribution to the capital requirements for infrastructure, industrial expansion, and the development of educational and other institutions will itself be strongly influenced by the strategy for agricultural development that is pursued.

The increase in demand for farm inputs by large scale, capital-intensive units effecting agricultural development within a dual-size structure will to a large extent be directed toward imports of farm machinery. Even if local assembly plants are established, the foreign exchange requirements for imported components will be large. The effect on domestic value-added and on nonfarm employment will be small. Conversely, a pattern of agricultural development similar to that pursued in Japan or Taiwan maximizes the positive interactions between the farm and domestic manufacturing sectors. It means a large increase in demand for simple, inexpensive farm equipment that is well suited to local manufacture by small and medium scale rural workshops; these workshops can be expected to employ capital-saving, labor-intensive techniques, and thus make a significant contribution to the expansion of nonfarm output and employment.

One important illustration of the interaction between the nature of the farm sector's demand for farm inputs and the resulting impact on domestic manufacturing output and employment is offered by the recent experience with the rapid expansion of tubewells in West Pakistan. There has been a parallel development of relatively large-bore public tubewells and of smaller capacity private tubewells. The latter have had a much greater total effect on the supply of irrigation water, and whereas the public program has relied mainly on imported equipment, the private tubewells have used pumps, diesel engines, coir string strainers, and other items of simple design produced in machine shops in rural areas. Many of these firms have expanded their activity and the range of products fabricated at a remarkably rapid rate [9].

An even more significant potential exists for the development of local manufacture of a widening range of improved farm implements cheap enough to enter into widespread use. Efforts in Pakistan and India to replace the traditional "stick plow" with an improved furrow-turning plow earlier met with only limited success, but the rise in farm cash income is increasing the ability of farmers to purchase such inputs. Moreover, the yield advantage of adequate preparation of the seedbed, efficient weed control, uniform and proper depth of planting, and optimum plant populations is very much greater with the new plant varieties and this has sharply increased the attractiveness of this type of innovation.[5]

An agricultural development strategy that would generate demand for simple and low cost equipment that lends itself to widespread adoption is attractive for two reasons. Such capital inputs complement abundant farm labor rather than effecting mass displacement of farm workers. Secondly, the inputs themselves can be manufactured by small and medium scale firms that employ fairly capital-saving, labor-intensive techniques. Economies of scale are relatively unimportant in the metal-working operations required for such items and can be offset easily by the lower wage rates that prevail in what Ohkawa has aptly termed the "semi-modern sector" of industry [23].[6] Okita's excellent analysis of Japan's experience with the parallel development of "modern" and "semi-modern" industrial sectors emphasizes the advantages of such a dual structure of industry in developing countries characterized by an abundance of labor and scarcity of capital [25, p. 382]. In addition to the advantages secured by the use of appropriate factor proportions, this concurrent development of small and medium scale firms has the further advantage of making it possible to tap sources of capital and entrepreneurial talent that the modern, large scale sector is not capable of mobilizing.

The seed-fertilizer revolution has more general implications with respect to the intersectoral flows of capital between agriculture and nonagriculture. The most immediate fiscal impact in Pakistan, and other countries where expanding domestic production is leading to rapid replacement of P.L. 480 imports, is the loss of the government revenues previously generated by the sale of these imports. Although rapid increase in farm cash incomes means a significant increase in the taxable capacity of the agricultural sector, the present tax structures are not income-elastic, and politically difficult decisions will have to be made in order to secure these offsetting increases in government revenues.

T. H. Lee's meticulous analysis [17] makes it clear that in Taiwan a net outflow of funds from agriculture contributed to capital formation and infrastructural investment in other sectors of the economy. But he emphasizes that the gross inflow of funds to finance key projects in agriculture was also of critical importance. For a number of developing countries, substantial investments in irrigation and drainage will be required to realize the potential benefits of the new varieties and heavier use of fertilizers. Ruttan and Ishikawa have even argued that because of the magnitude of the agricultural investments required to expand output to meet the requirements of a rapidly growing population, the agricultural sector in contemporary developing countries may require a sus-

[5] Programs to screen, test, and design prototypes of promising items and to carry out market feasibility studies and to organize farm demonstrations could accelerate the development See [21]. A sharp distinction should be made between such programs to encourage the emergence of viable units which use limited but appropriate capital equipment and an employment-relief program such as India's scheme to foster hand-operated spinning machines (the Ambar Charkha) that use more capital per unit of output than a modern mill [29, pp. 240, 242].

[6] The type of dual structure to which Ohkawa refers is widely characteristic of the industrial sector in developing countries as different as Japan and Nigeria For the latter, see [10] and [16].

tained net inflow of capital from the industrial sector [27, p. 22] [14, Ch. 4]. If valid, this would be a gloomy conclusion indeed, since rapid population growth also increases the capital requirements for structural transformation.

Perhaps the most significant single implication of the seed-fertilizer revolution is that the capital requirements for a given rate of increase in agricultural production can be reduced. The much more favorable input-output relationships now available imply that the expansion of irrigated area need not be as rapid as would otherwise be required, and that the benefit-cost ratios of irrigation investments can be much more favorable.

## IV. CONCLUDING COMMENTS

The spectacular successes achieved by agricultural scientists and the world fertilizer industry have abruptly altered the dimensions of the world's food and population problem. Although still difficult, the problems posed by rapid growth of population and labor force in the underdeveloped countries now appear to be manageable. Over the next two or three decades, the improved production possibilities resulting from the seed-fertilizer revolution offer the hope of rapid and relatively low cost increases in agricultural output; and these can be achieved by an intensification of agricultural production which offers the possibility of absorbing a considerable fraction of the growing labor force into productive employment.

This conclusion is especially significant for countries in which the transformation of the economic structure has been limited, where the farm labor force still bulks large in the total and will continue to increase in absolute size for several decades at least. In the light of the sectoral interdependence between agriculture and nonagriculture in the process of economic growth, the advantages of a broad thrust, unimodal approach to agricultural development, similar to the pattern pursued in Japan and Taiwan, appear to be very great for such countries.[7] What remains unclear is the actual mix of policies needed to influence the pattern of agricultural development in the desired direction. Certain policy implications seem fairly evident: for example, confining government subsidies on farm inputs to items that are essentially complementary to the abundant on-farm resources, and imposing import duties and taxes on inputs that are unduly labor displacing. Much needs to be done, however, in developing analytical techniques for quantifying such judgments. There is an acute need to determine whether, in a particular situation, tractors or other inputs are in fact, unduly labor displacing, and to calculate the level of duty or taxation that should be imposed to make the private profitability of investment in such inputs reflect their social marginal productivity. Although many countries need to devise ways to increase agriculture's contribution to tax revenue as farm cash incomes rise, there is no consensus as to how this can best be done without blighting the development of agriculture.

There is also a need for better understanding of the effects of alternative policies relating to land tenure and taxation on the pattern of agricultural development. What accounts for the fact that in Japan and Taiwan management units in agriculture were uniformly small, in spite of the fact that both countries had a highly skewed pattern of land ownership during their critical periods of agricultural development? There do not appear to have been any attempts to account for the very different pattern that prevails in much of India and Pakistan, where large land holdings have often been operated as large management units with hired labor. The seed-fertilizer revolution has given a special urgency to this question because of the tendency for large farmers to acquire tractors and to hire fewer workers or to move their tenants off the land that they are now renting. Efficient implementation of land reform measures that put a ceiling on farm holdings would presumably encourage a pattern of agricultural development similar to that pursued in Japan and Taiwan. In fact, the very limited and unstable changes in tenure arrangements that have been carried out in India may well have had an opposite effect [26, p. 292]. Ceilings on land rentals may accentuate a trend toward a bimodal pattern of agricultural development that will

[7] A broadly based approach may also yield important indirect benefits. It has been argued elsewhere that widespread involvement of the farm population in the dynamics of the seed-fertilizer revolution is likely to create an environment more propitious for the spread of family planning than that which could be expected if the expansion of farm output and sales were concentrated in a subsector of large scale, capital-intensive units [15, p. 285].

create social problems more serious than those associated with the high rental payments that farmers are prepared to pay when there is excess demand for land.

Implicit in the present analysis is the view that wage subsidies are not a promising policy instrument for accelerating employment. In large scale, capital-intensive industries, such as nitrogen fertilizer production, the elasticity of employment to wage rates is certainly very low since wage costs are such a small fraction of total costs. On the other hand, it would be costly and difficult to administer such a program among the small scale firms of the "semi-modern sector" of industry which, in fact, normally pay lower wage rates because of a differentiated salary structure. Enthusiasm for a program of wage subsidies that would lead to endorsement of large corporate farms as a major element of agricultural strategy (because such farms might make the administration of wage subsidies feasible in the farm sector) would certainly seem to be misguided in light of the present analysis.

It is already apparent that the seed-fertilizer revolution has given important breathing space with respect to the food supply problems associated with rapid population growth. The present opportunities, however, are the result of a disequilibrium situation. A significant part of the cumulative advance in agricultural science and in fertilizer production technologies has quite abruptly become accessible to many of the tropical and subtropical regions of the underdeveloped world. Once these possibilities for dramatic shifts from old to new production functions have been substantially exploited, and our projections suggest that in West Pakistan this may well have taken place by 1985, the further opportunities for rapid and low cost increases in farm output will probably be much more limited. It is important that the present opportunities be exploited in ways that will have a maximum positive impact on overall economic growth and modernization.

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## The Green Revolution: Cornucopia or Pandora's Box?

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The application of science and technology to traditional agriculture has begun to produce dramatic results, above all in Asia. The rapid expansion of certain food grains in the developing world is being particularly widely heralded, and justly so, as the "Green Revolution." The discussion of the phenomenon tends to cluster around two views. On the one hand, some observers now believe that the race between food and population is over, that the new agricultural technology constitutes a cornucopia for the developing world, and that victory is in sight in the "War on Hunger." Others see this development as opening a Pandora's box; its very success will produce a number of new problems which are far more subtle and difficult than those faced during the development of

the new technology. It is important to give careful attention and critical analysis to both interpretations in order to be optimistic about the promise of the Green Revolution where justified, and at the same time to prepare for the problems that are now emerging. The Green Revolution offers an unparalleled opportunity to break the chains of rural poverty in important parts of the world. Success will depend upon how well the opportunity is handled and upon how alert we are to the inherent consequences.

It is now generally known that major technological breakthroughs in food production are believed to have lifted the spectre of famine in the immediate future and to have postponed the prospect of Malthusian population disaster. Startling developments have been accomplished in wheat, rice and corn—major food staples in much of the developing world. The possibilities for doubling or even tripling production are based upon new high-yield varieties coupled with adequate supplies of water, fertilizer, pesticides and modern equipment. Overnight, the image of agriculture in the developing countries has changed from that of an economic backwater to that of a major potential contributor to overall development. The new varieties are rapidly spreading both within countries and across national boundaries. A recent estimate of the International Agricultural Development Service of the U.S. Department of Agriculture reveals that in Asia alone the estimated acreage planted with these new high-yield varieties rose from 200 acres in 1964–65 to 20 million in 1967–68. Traditional food-importing nations like the Philippines and Pakistan are becoming self-sufficient and have the prospect of becoming net food exporters.

It will be no easy task to achieve the potential increased production offered by the new technology, particularly when it involves millions upon millions of diverse farms and farmers scattered over the countryside. If the increased production is in fact obtained, this will automatically produce a whole new set of second-generation problems which must be faced if development is to be sustained and accelerated. Therefore, two considerations need to be borne in mind. First, there is reason to believe that the further spread of new varieties will not be as fast as early successes might suggest. Second, the new problems arising out of the spread of the new technology, whatever its speed, needs to be foreseen and acted upon now. The probable developments in each case have the greatest significance for economic growth and for the conduct of international relations.

II

The reasons for believing that the new technology will not in fact spread nearly as widely or as rapidly as supposed and predicted include, first, the fact that the availability of irrigated land imposes at least a short-run limit to the spread of the new high-yield varieties. Most of these require irrigation and careful water control throughout the growing cycle. In most Asian countries about one-fourth to one-half of the rice lands are irrigated; the remainder are dependent upon monsoons and seasonal rains. The speed with which additional land can be converted to the new technology depends on the rapidity with which new irrigation facilities can be constructed; and here the high capital costs are likely to be a retarding factor.

Large-scale irrigation projects can seriously strain the investment capacity of developing nations. For example, the massive Mekong River development scheme, involving Laos, Cambodia, Viet Nam and Thailand, has been estimated to require a capital investment over the next 20 years of about $2 billion, roughly 35 percent of the annual national income of the four countries involved and exceeding the annual net new investment of all the countries of Southeast Asia combined. Further, significant additional costs are involved in converting existing irrigation systems to the requirements of modern agriculture Many of the old gravity irrigation systems were not designed to provide the sophisticated water controls demanded by the new varieties. (For example, each plot must be controlled separately throughout the growing season.)

Second, there are doubts about the ability of existing markets to handle the increased product. Storage facilities and transport are inadequate and crop grading often deficient. Not only must the marketing system be expanded to handle a larger output; there also is an increased need for farm supplies and

equipment. Fertilizers, pesticides and insecticides must be available in the right quantities, at the right times, and in the right places. Given the inadequacy of the agricultural infrastructure, the need to expand and modernize marketing systems is likely to reduce the pace of the Revolution.

Because many of the new varieties, especially rice, do not appeal to the tastes of most consumers, it is difficult to calculate the size of the market. Some argue that until newer varieties which are closer to popular tastes are developed, the market will be limited.

Third, the adoption of the new technology is likely to be much slower where the crop is a basic food staple, grown by a farmer for family consumption. Such farmers are understandably reluctant to experiment with the very survival of their families. Peasant producers are obviously far more numerous in the developing world than are commercial farmers and the task of converting them to a more modern technology is considerably more difficult. So far, spectacular results have been achieved primarily among the relatively large commercial farmers. Some semi-subsistence farmers have begun to grow the new varieties, but the rate at which they adopt them may be slower.

Fourth, farmers must learn new farming skills and expertise of a higher order than was needed in traditional methods of cultivation. The new agronomic requirements are quite different as regards planting dates and planting depths; fertilizer rates and timing; insecticide, pesticide and fungicide applications; watering and many others. Unless appropriate extension measures are taken to educate farmers with respect to these new farming complexities the higher yields will not be obtained.

Fifth, many of the new varieties are non-photosensitive and the shorter term will allow two or three crops per year instead of one. Multiple cropping is good, but there may be difficulties if the new harvest comes during the wet season without provision having been made for mechanical drying of the crop to replace the traditional sun drying. In addition, there may be resistance if the new harvest pattern conflicts with religious or traditional holidays which have grown up around the customary agricultural cycles.

Sixth, failure to make significant institutional reforms may well be a handicap. There is evidence in several Latin American countries that a failure to make needed changes in policies now detrimental to agriculture, or a reluctance to effectuate the institutional reforms required to give real economic incentives to small farmers and tenants, has been primarily responsible for the very slow spread of Mexico's success with new varieties of wheat and corn to its neighbors to the south.

From all this one may deduce that the "first" or "early" adopters of the new technology will be in regions which are already more advanced, literate, responsive and progressive and which have better soil, better water management, closer access to roads and markets—in sum, the wealthier, more modern farmers. For them, it is easier to adopt the new higher-yield varieties since the financial risk is less and they already have better managerial skills When they do adopt them, the doubling and trebling of yields mean a corresponding increase in their incomes. One indication of this is the large number of new private farm-management consultant firms in the Philippines which are advising large landlords on the use of the new seed varieties and making handsome profits out of their share of the increased output.

As a result of different rates in the diffusion of the new technology, the richer farmers will become richer. In fact, it may be possible that the more progressive farmers will capture food markets previously served by the smaller semi-subsistence producer. In India, only 20 percent of the total area planted to wheat in 1967–68 consisted of the new dwarf wheats, but they contributed 34 percent of the total production. Such a development could well lead to a net reduction in the income of the smaller, poorer and less venturesome farmers. This raises massive problems of welfare and equity. If only a small fraction of the rural population moves into the modern century while the bulk remains behind, or perhaps even goes backward, the situation will be highly explosive. For example, Tanjore district in Madras, India, has been one of the prize areas where the new high-yield varieties have been successfully promoted. Yet one day last December, 43 persons were killed in a clash there between the landlords and their landless workers, who felt that they were not receiving their proper share of the increased prosperity brought by the Green Revolution.

III

Other experts argue that the new technology's stimulus to production and income cannot be stemmed. It is true that the rapidity with which the new seed varieties have spread in country after country belies the customary view of an inert, unresponsive peasantry. In 1965, India began a program of high-yield varieties which set a goal of 32.5 million acres by 1970–71; last year's crop season saw 18 million acres already planted, which contributed to the most successful year in recent Indian agricultural history (some 100 million tons of food grains, 11 million over the previous record year of 1964–65). Self-sufficiency in food grains is predicted in three or four years. Other countries are experiencing similar situations where the demand for the new seeds is outstripping the available supplies and black markets are even developing in seeds and fertilizer.

Nevertheless, if we assume that the new varieties will continue to live up to expectations and spread rapidly and widely, the increased production will in turn lead to a new set of difficulties. First, large tracts planted in one of the new varieties may be susceptible to disease and infestation which could cause massive losses Heretofore, reliance upon seed selected by individual farmers meant that neighboring farms growing the same crop usually planted two or more different varieties or strains. This heterogeneity provided a built-in protection against widespread plant diseases, since not all varieties are equally susceptible. But where a single variety is introduced, covering large contiguous areas, the dangers of pathologic susceptibility are multiplied. For example, the new wheat introduced from Mexico into the Indo-Gangetic belt in India and Pakistan has involved a small range of genotypes—and the same has been true in Iran, Turkey and certain Middle Eastern countries. Any change in the spectrum of races of wheat rust in any of these countries could threaten the wheat crop on a massive scale, since it would involve the entire area.

Two steps are necessary to avoid these dangers: first, a diversified breeding program which can continually produce new varieties; second, an able and well-organized plant protection service which can quickly identify dangerous outbreaks and initiate prompt steps to combat them Both activities must rely primarily upon national organizations rather than the regional or international ones Both demand a skilled, well-trained staff. Some nations have recognized these dangers and are taking steps to meet them, but others still have not been made sufficiently aware. Aid givers—public and private—who are responsible for promoting the new varieties bear an equal responsibility to promote indigenous research and plant protection services The outbreak of any major disease which wipes out the harvest of thousands of farmers is far more likely to be blamed on the producers and spreaders of the miracle seed than on Fate. Agricultural development could be set back several decades.

Second, it is vitally important to expand the entire complex of services and industries required to achieve the higher production. Any government or foreign-aid agency which distributes the "miracle" seed but fails to provide the insecticide and fertilizer in the appropriate quantities when and where needed is courting political disaster; unless these inputs are available and used, some local, traditional varieties will outyield the new ones. A seed industry, agricultural chemical plants, processing and storage firms, factories producing hand sprayers, dusters, water pumps and engines—these are just a few of the agriculturally related industries which must develop if the Revolution is to take hold.

The skills and the capital needed cannot be provided solely by the public sector. Private capital must also be utilized. In a few countries the spread of the new technologies has already forced an abrupt departure from the previous practice of having government agencies serve as the major or sole distributor of the required inputs. Private industry, especially American, has stepped in to provide a new, more dynamic pattern of distribution. In the Philippines, for example, ESSO has become a major distributor of fertilizer and agricultural chemicals. Frequently, such ventures have involved links with local firms. In India, the International Minerals and Chemicals Corporation, with the Standard Oil Company of California, built a fertlizer plant with a yearly capacity of 365,000 tons; the U.S. firms provide the management but control is held by an Indian firm. Storage silos, seed multiplication firms and even integrated farm-to-retail firms are just a few of the activities where private U.S. resources are being harnessed to serve the Green Revolution.

Equally important are the increased farm services which are required, particularly agricultural credit. For example, from studies conducted at the Inter-

national Rice Research Institute, it is estimated that whereas the total cash costs of production for the average Filipino rice farmer using traditional methods and varieties is about $20 per hectare, the cost rises to $220 when the new, high-yielding IR–8 is grown. Although the yield may increase threefold, leading to a net return four times greater than with traditional varieties, the farmer must have access to substantially greater credit to finance his operations. Especially for the poorer farmers with low cash reserves, who may want to adopt the new varieties, the village moneylender and merchant will not be adequate unless they in turn have access to additional funds. Indeed, the Green Revolution must be accompanied both by an increase in the amount of credit available and by the expansion and modernization of credit institutions and mechanisms. Tapping the capital markets in the modern urban sector must be encouraged, and ways must be found at the village level to mobilize local capital, especially the increased savings which are possible from higher farm incomes. The Green Revolution will generate increased cash which, if properly marshalled, can contribute to capital formation and agricultural progress.

Third, much more attention must be devoted to marketing the increased output. Where there has been semi-subsistence agriculture, the impact of the new technology upon the *marketed* product is even greater than on total production. If the crop is a food staple and if the peasant farm family traditionally consumes some 70 to 80 percent of its total product each year, a doubling of output does not lead to a doubling in the amount retained for family consumption. Some modest increase in consumption is likely, but the bulk of the increased production will enter the market. Thus a doubling in yields in a semi-subsistence agriculture usually leads to much more than a doubling of the amount sold.

The impact of this explosive increase upon the traditional marketing network and storage capacity can be calamitous. The case of India is illustrative. During the past crop year, India experienced a marvelous increase in food-grain production, but the marketing network and storage facilities were not prepared to cope with it. The result can be seen in the mountains of food-grain stored in schools and in the open air under conditions which are apt to reduce if not negate the gains. The food-deficit psychology which underlies the failure of planners and policymakers to anticipate these results is not limited to the developing nations. Aid givers were equally surprised. Strangely, the lessons of the Indian experience do not yet seem to have affected the thinking and planning of other nations which are promoting the new technology.

Fourth, the slowness with which the food-deficit psychology dies also has an important consequence in terms of government pricing policies. The fact that agriculture, even semi-subsistence agriculture, does respond to price, is only gradually becoming accepted. But the shock which quantum jumps in food production may have on domestic prices has not been sufficiently appreciated. The downward pressure on prices, especially where transport is deficient and storage is inadequate, may in fact be so severe as to have a disincentive effect upon producers. Unless adequate attention is given to developing a sound pricing policy to prevent excessive dampening of incentives, the spread of the new technology may in fact be cut short before any "takeoff" has occurred. Premature discouragement could produce a reversion leading to a slowing up in food production or even a rejection of the new technology.

It has been amply demonstrated throughout the world that peasant and subsistence farmers are responsive to favorable prices, provided the return is real and they receive the benefit. For example, from 1951–53 through 1961–63, the farmers of Thailand in response to favorable prices increased their exports of corn at an average annual compounded rate of 35.8 percent; casava, 25.0 percent; and kenaf, 43.8 percent. Filipino farmers responded to a governmental price-support program for tobacco by changing from native to Virginia tobacco and then booming production from 3 million kilos in 1954 to over 30 million kilos in 1962. The list of crops where peasant farmers have responded to favorable prices is large—rubber, oil palm, coffee, jute, wheat, barley, sorghum, millet, gram, cotton. Thus, if the full potential offered by the new technology is to be realized, every effort must be made to insure that there is in fact a significant return to the producer and that the rapid rise in output does not lead to a counter-productive slump in prices.

Fifth, the goals of increased food production are frequently couched in terms of some desirable, minimal standards of nutrition. Such nutritional goals are commendable, but they can be attained only by individuals who have the income with which to purchase the better diet. Effective demand for food depends upon both the income of the demanders and the price of the food. If the increased production

leads to lower costs and prices, then consumers will be able to increase their food purchases and hopefully to raise their levels of nutrition Equally important is the need to increase incomes so that the greater production entering the market can be purchased. The food problem in a developing world is both a problem of production and supply and a problem of demand and income. Unless the higher levels of effective demand materialize, the prospect will be market gluts, price depression and, in certain cases, shifts by the farmers away from the higher-yielding varieties. Hence, every effort must be made both to reduce the unit costs of the increased food output and to augment the incomes of consumers who purchase food; otherwise, the second bowl of rice will not be bought—despite the technical feasibility of producing it

Sixth, one of the major avowed aims of most nations which are eagerly promoting the Green Revolution is to achieve self-sufficiency in food production. In Southeast Asia, for example, the Philippines already claims to have become self-sufficient. Malaysia predicts that she will be self-sufficient by 1971; Indonesia by 1973. Some believe that these target dates are overly optimistic. But if the rice-deficit nations of the region such as Malaysia, Indonesia and the Philippines eventually become self-sufficient by successfully adopting the new technology, what will happen to the rice-surplus nations like Burma and Thailand whose economies are heavily dependent upon rice export? To whom will they sell their rice? Self-sufficiency will not only be detrimental to the rice-exporting nations, but will reduce one of the few areas of economic interdependence in the region. Unless action is taken in advance to offset the predictable impact of the new technology, hopes of promoting regional economic integration will be substantially reduced. Whether or not one agrees with the goal of self-sufficiency for these nations, the policies have been adopted and will be pursued. Many developing nations spend some 30 percent of their foreign exchange on food imports and wish to eliminate this drain as well as the irritation of chronic deficits in domestic production. We should anticipate the predictable consequences of these policies—in this case major economic dislocations in trade—so that we can be equally ready with developmental efforts or foreign assistance to reduce the dimensions of the problem. Unless the exporting nations take immediate stock of their prospects and seek to diversify their agriculture, the impact of such trade distortions could have major consequences for their economies and pace of development.

Seventh, a critical question is whether these technological developments are a "once-and-for-all" phenomenon. How likely is it that new technological improvement will continue to be made? The application of science to agriculture over the last 300 years has resulted in a tenfold increase in yield per acre on the best farmed lands in the temperate zone. This expansion is what led to the production controls introduced by the surplus nations, such as the United States, to keep demand and supply in reasonable balance. Today's Green Revolution is the result of a similar application of science to agriculture in the developing world. But it should be noted that the institutionalized application of science is largely concentrated at present in food crops. Before World War II, primary attention in agricultural research in the developing world was devoted to the major crops—rubber in Malaysia, sugar in the Philippines, coffee in Kenya, palm oil in Nigeria, coffee in Brazil, bananas in Honduras. Staple food crops were either ignored or received scant attention. Thus the successes of the recent application of science to peasant agriculture could be interpreted as an exploitation of a "technical gap" in food crops left by years of neglect. If current developments merely represent a "catching-up," then as soon as population overtakes current developments, we are back to "square one."

Much will depend upon whether or not the necessary manpower is trained in each country to provide a continuing human resource which can produce a constant stream of new technology. The manpower trained in the Rockefeller Foundation's Mexican program has always been a greater contribution, in my view, than the new varieties. Successful adoption should not deflect attention from the importance and role of continuous agricultural research. The development of indigenous competence to engage in agricultural research is critical and becomes even more critical as the new varieties are adopted. The target should be not *a* new technology but ever-new technology, and this requires skilled manpower.

These are only a few of the possible consequences of the successful spread of the new technology. There are several broader consequences and issues which can be raised only as questions in this brief presentation:

To what extent will the diffusion of the new technology accentuate the displacement of rural people and heighten the pace of migration to the cities? If

higher yields per acre, multiple cropping plus mechanization, force surplus manpower out of agriculture, what are prospects for increased employment in industry and services to absorb this manpower?

For the average developing nation the Green Revolution means that instead of devoting two-thirds to three-fourths of its agricultural resources to food production, these resources may now be shifted to other higher paying crops. The question then becomes, what crops and for what markets?

If agriculture becomes more modern, dynamic and wealthy, will the non-agricultural sector allow agriculture to retain a significant share of this increased income or merely follow the previous patterns of taxing agriculture for non-agricultural development?

What will be the political significance of these changes if successful adoption of the new technology leads to an economically invigorated and strengthened rural population—almost invariably a large majority in developing nations? Will rural-based political parties and movements emerge to alter the recent dominance of urban centers?

What will be the global effect of a food explosion in the tropical and sub-tropical world? Will such developments lead to an improved reallocation of productive specialization among the developed and developing world, or will nationalistic trade barriers continue to flout natural comparative advantages?

One final danger lies in assuming that there is no longer an urgent need for measures to reduce rates of population growth. Quite the contrary. While the new developments are a splendid gift of time to allow a holding operation, effective population measures continue to be essential. Whether one assumes a growth rate of 2.5 or 3 percent, the inexorable fact is that, give or take a few years, the population of the developing world will double in about 25 years.

The significance of the food-population problem is more than humanitarian and developmental; it also has critical implications for the conduct of international relations. Relations between nations are often profoundly affected by long-run forces over which men can exercise only limited control in the short run. The food-population race is an excellent example of such a set of forces. Predictions regarding both population and food, as well as their interaction over varying lengths of time, must be taken into account in the conduct of developmental assistance, not only by aid-giving nations and international organizations, but by the governments of developing nations themselves. Policies and programs designed to win the race between food and population may have unintended, though often predictable, consequences which may have a very broad impact.

IV

Charles Malik once said that "one of the principal causes of both international conflict and internal strife is unfounded expectations. These are based ultimately either on deception or on a belief in magic."[1] What we have in hand seems to many people to approach magic; let us hope that it does not become the source of deception.

To speak of the possible consequences and problems associated with the next phase of the Green Revolution should not be misinterpreted as a plea for the suppression of the Revolution because, like Pandora's box, it will lead to even greater problems than those it was designed to eliminate. On the contrary, I would strongly argue that the list of second-generation problems is a measure of what great opportunities exist for breaking the centuries-old chains of peasant poverty. They also demonstrate how closely interrelated are the various factors which impel or retard agricultural development. This complex interrelationship makes interdisciplinary research and coöperation vital if the current problems are to be solved and future ones anticipated. The most realistic prediction is that each country is likely to experience a different set of these problems and that there will be variations among countries between the two extremes of optimistic and pessimistic prognoses.

The quiet, passive peasant is already aware of the modern world—far more than we realize—and he is impatient to gain his share. The Green Revolution offers him the dramatic possibility of achieving his goal through peaceful means.

It has burst with such suddenness that it has caught many unaware. Now is the time to place it in its long-range perspective and to engage in contingency planning so that we may respond flexibly and quickly as the Revolution proceeds. Perhaps in this way we can ensure that what we are providing becomes a cornucopia, not a Pandora's box.

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[1] Charles H. Malik, "What Shall It Profit A Man?", *Columbia Journal of World Business*, Summer 1966

# Food Supplies and Economic Growth in Developing Countries—The 1970's

(Lyle P. Schertz)

*(Presented at the Annual Meeting of the Western Agricultural Economics Association, Oregon State University, Corvallis, Oregon, July 22, 1969. Mr. Schertz is Assistant Administrator for International Development, Foreign Agricultural Service, U S. Department of Agriculture.)*

In the mid-1960's the spectre of food scarcity emerged as a major world issue. Rapid population growth continued in developing countries. Failure of the monsoon on the Indian subcontinent caused cereal production to plunge. U.S. grain stocks available for concessional food assistance had declined and were limited.

Today, only a few years later, we witness a "green revolution" in the developing countries. And the world has new confidence that food crises in these countries are a thing of the past.

I want to review the evolution of these events. But even more I want to discuss two new challenges that confront the developing countries in the 1970's: (1) relating food production to world trade, and (2) expanding employment to meet population increases. The recent progress could easily cloud our awareness and preparation for these challenges which are much more complex than merely increasing production.

## Two Decades of Change

The recent increases in food production have occurred against a background of two decades of change in the developing countries, which led to their increased dependence on cereal and fertilizer imports from the developed countries—in many cases on a concessional basis. The two decades can be roughly divided into four periods.

| | |
|---|---|
| 1950's | Growth |
| 1960–64 | Deceleration |
| 1965–66 | Crisis in South Asia |
| 1967–68 | Recovery and Acceleration |

### *The Four Periods*

During the 1950's per capita food output in the developing countries increased an average of 0.6 percent a year. (Figure 1) This growth reflected increased total food output of three percent a year against a population growth rate of 2.4 per-

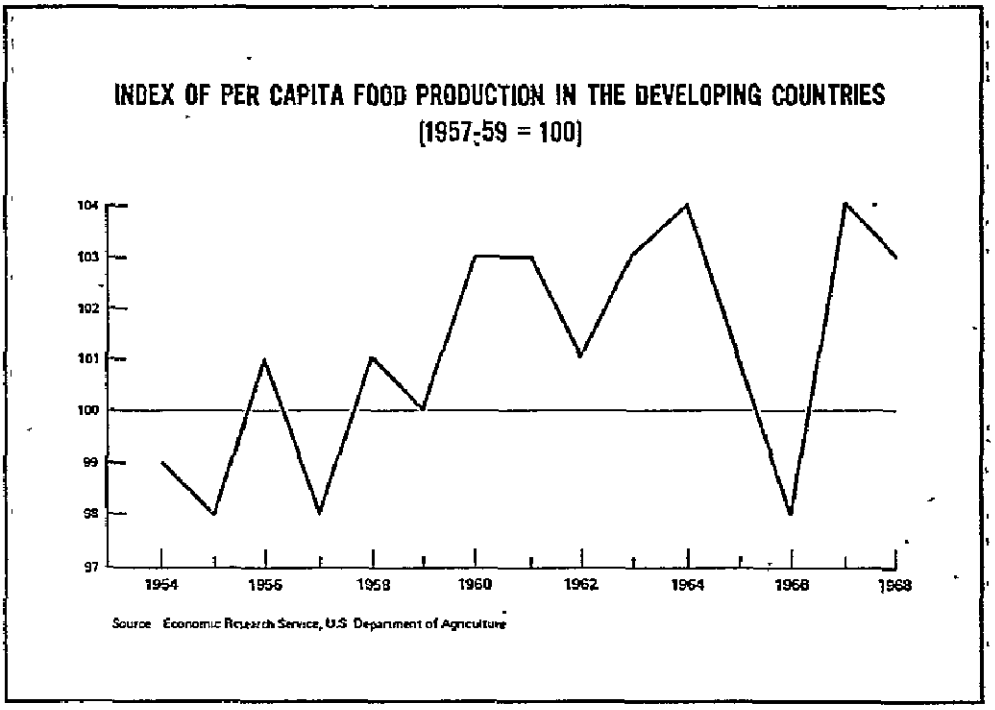


Figure 1

cent. The dependence on the developed world for food increased. Net cereal imports by the less developed countries increased from a 1951–55 yearly average of slightly less than six million tons, to 15 million by the end of the decade.[1]

The growth thrust of the 1950's—war recovery and national independence—faded, however, in the early 1960's. The rate of increase of food output slowed, while the rate of population growth increased. During the deceleration period—1960–64—per capita food production remained above the 1957–59 levels. But increases in food production did not keep pace with demand. And the dependence on the developed countries for cereal and fertilizer imports continued to rise. By 1964 the developing countries were importing 20 million tons of cereals a year on a net basis. Fertilizer imports by the developing nations in the mid-1960's were 2.6 times higher than a decade earlier.[2] While the 1950's brought progress with modest yield increases, the early 1960's demonstrated the need for more intensive agriculture if the developing countries were to feed their people.

During these first two periods—growth and then deceleration—development programs emphasized industry. Few countries gave priority to agriculture even though technical assistance helped build institutions to contribute to a modern agriculture.

Then the crisis of the mid-1960's struck South Asia. Failure of the monsoon on the Indian subcontinent caused cereal production to falter dramatically; India was on the verge of a famine. Per capita food production in the developing countries—heavily weighted by South Asia—dropped six percent to levels equal to the lows of the mid-1950's. Increases in food production in Latin America and Africa barely kept pace with population growth. Net cereal imports of the developing countries topped 28 million tons. Increased import needs of the Communist countries, as well as reduced stocks in the major exporters, especially the United States, accentuated the crisis.

From this crisis, and the ensuing reactions which demanded priority for agriculture, came a period in the developing countries of recovery and acceleration. Many factors contributed—improved weather, changes in domestic policies, reduced availability of U.S. food aid, emphasis on self-help, more emphasis on agriculture in assistance programs, and accumulated payoffs from long-term efforts to improve institutions serving agriculture in the developing countries. (23)

*Responsive Crop Varieties*

But the outstanding factor was the development and introduction of high-yielding, fertilizer-responsive dwarf varieties of wheat and rice in Asia.[3] Scientists with the Rockefeller and Ford Foundations literally remade the wheat and rice plants into more efficient converters of soil nutrients, water, fertilizer, and solar energy.[4] As a result, the new varieties, with associated inputs, yield up to two and in some cases three times as much as traditional varieties under field conditions. They not only yield more, they mature faster and are photo-period insensitive thus making it possible for farmers to grow two or three crops where previously only one could be grown.

Many farmers in Asia are planting the new varieties of wheat and rice. Acreage increased from only 200 in 1964/65 to nearly 16 million in 1967/68 and over 27 million this year—approximately 16 percent of the wheat acreage and seven percent of the rice acreage in non-Communist Asia. (7) (27)

Introduction of the new varieties and their impact on national yields vary widely. In Asia, the growing of the new wheat varieties has been most extensive

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[1] Calculated from data in (11) and (12). Totals exclude Japan, Mainland China, Republic of South Africa, and Argentina

[2] Imports during 1963/64 and 1964/65 averaged 255 million metric tons compared to an average of 0 97 million tons in 1953/54 and 1954/55 Computed from data in (10).

[3] Defining "high-yielding varieties," as Dalrymple points out, is not easy (7) The term is used in this paper to refer to varieties or descendants-of-wheat varieties developed at the International Wheat and Maize Improvement Center in Mexico City (CIMMYT), and rice varieties developed at the International Rice Research Institute (IRRI) in the Philippines (as well as two rice varieties developed elsewhere and widely used in India: ADT–27 and Taichung Native No. 1). Other improved varieties which have been in use for some time in Ceylon, Taiwan, and Korea are not included.

[4] There have, of course, been technological yield breakthroughs with other crops but I shall concentrate on wheat and rice because of their importance in the developing nations. The history of Rockefeller Foundation plant improvement programs for these and other crops through the early 1960's is discussed in detail by Stakman et al. (25) More recent information on corn programs in developing nations is provided by Dalrymple (8) and Eberhart (9). For a review of advances in sugar cane and bananas, see Ruttan et al. (21)

in West Pakistan and India, where they accounted for almost one-fifth of the wheat area in 1967/68 and more of the crop now being harvested. (Table 1). Reflecting different government policies and growing conditions, the acreage planted to new rices varied from less than one percent in East Pakistan, to five percent in India, to 20 percent in West Pakistan.

TABLE 1.—HIGH-YIELDING VARIETIES (HYV): ESTIMATED PLANTED AREA, ASIA, 1967–68

[Acres in thousands]

| Country or region | Rice | | | Wheat | | |
|---|---|---|---|---|---|---|
| | HYV [1] | All varieties | HYV percent of total | HYV [1] | All varieties | HYV percent of total |
| East Asia: | | | | | | |
| Burma | 7 | 12,800 | (2) | | | |
| Philippines | 587 | 7,500 | 7.8 | | | |
| South Vietnam | 2 | 5,700 | (2) | | | |
| South Asia: | | | | | | |
| Afghanistan | | | | 65 | 5,800 | 1.1 |
| India | 4,410 | 90,700 | 4.9 | 7,270 | 36,900 | 19.7 |
| Nepal | | | | 61 | 300 | 20.3 |
| East Pakistan | 166 | 24,400 | 0.7 | 33 | 200 | 16.5 |
| West Pakistan | 10 | 3,500 | 0.3 | 1,800 | 14,800 | 12.2 |
| West Asia: Turkey | | | | 420 | 20,000 | 21.0 |
| Total Asia | 5,182 | 191,000 | 2.7 | 9,649 | 90,000 | 10.8 |

[1] See definition of high-yielding varieties in text, footnote 3.
[2] Negligible

Source. Compiled from references 7 and 27.

Yields have obviously increased. (Table 2, Figure 2) But how much of the increase can be attributed to the high-yielding varieties? Willett is perhaps the first to try to make a comprehensive estimate of the effect of the new varieties on overall production in South and Southeast Asia. (27, pp. 14–15) He estimates that the new rice varieties increased 1968/69 production by nine percent; the wheat varieties increased 1968/69 production by 20 percent. In terms of production, this would be equivalent to 14 million tons of rice and eight million tons of wheat. It would represent eight percent of world rice production and three percent of world wheat production.

My own feeling is that Willett's estimates may be high since rice production in the developing countries of Asia in 1968 was only 15 million tons above the 1960–64 average and 1968 wheat production was up 13 million tons. But no one can be sure in part because it is difficult to sort out the effects of weather during this period.

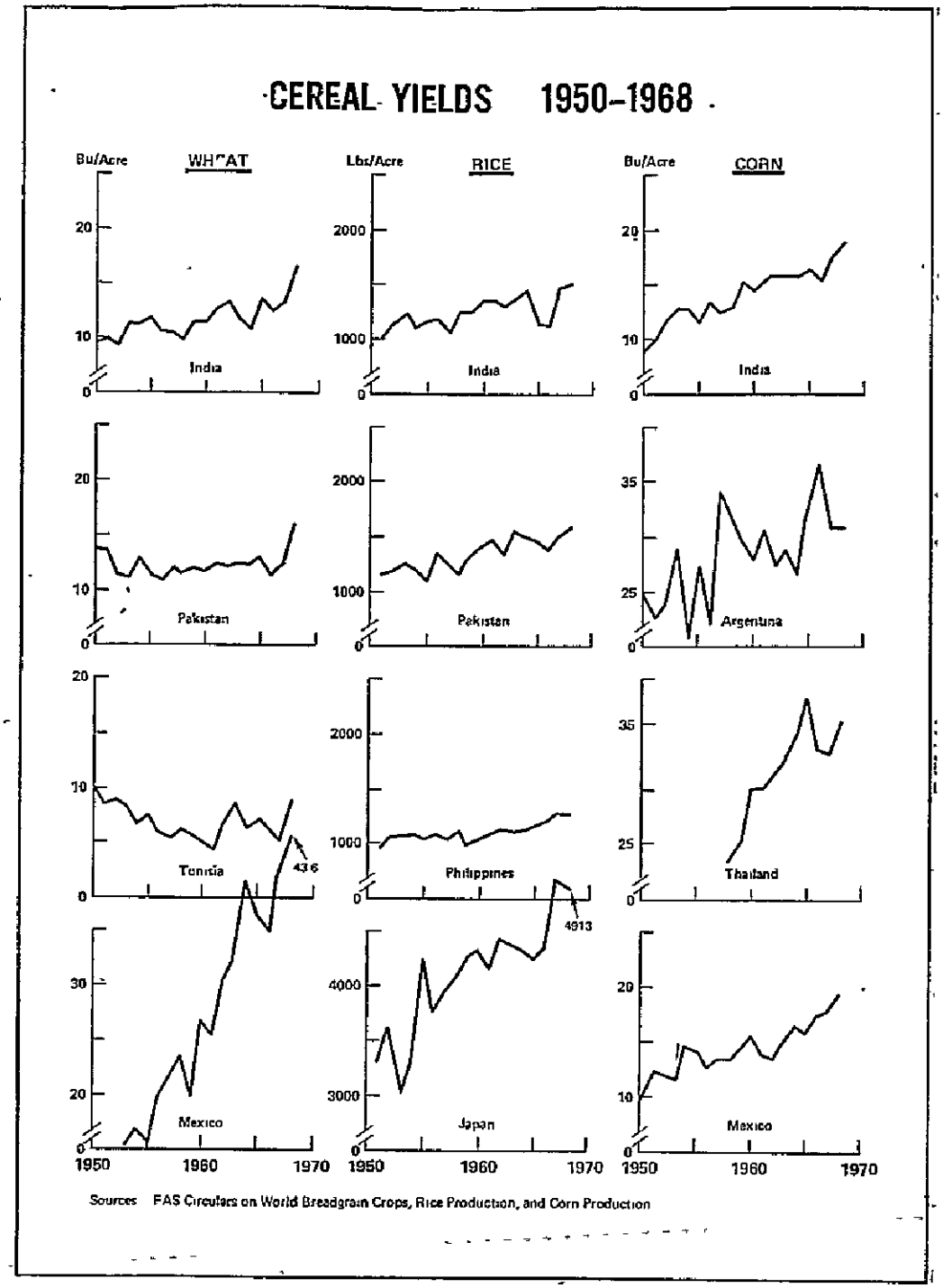
TABLE 2.—GRAIN YIELDS: PERCENTAGE INCREASE FROM 1960–64 AVERAGE TO 1968

| Country | Wheat | Rice | Corn |
|---|---|---|---|
| India | 39 | 10 | 21 |
| Pakistan | 24 | 8 | (1) |
| Ceylon | (1) | 4 | (1) |
| Turkey | 8 | (1) | (1) |
| Tunisia | 39 | (1) | (1) |
| Thailand | (1) | 2 | 17 |
| Philippines | (1) | 16 | 10 |
| United States | 13 | 20 | 26 |

[1] Data is unavailable.

Source: Compiled by Ronald Jones, FAS, from Foreign Agricultural Service Circulars.

FIGURE 2




Still, it is clear that the production functions for cereal growing in several developing countries have changed dramatically from only a few years ago. The high-yielding varieties of wheat especially are much more widely adaptable, have spread faster and further, and have yielded more than anyone would have guessed as recently as two years ago. The introduction of these new varieties have set in motion many other changes—economic, social, and political—the so-called green revolution. (4) (26)

Thus, a number of the developing countries approach the 1970's experiencing a turbulence of change in agriculture. Many issues come to the front. These have

often been referred to as "second generation" problems. Hardin suggests that science and technology are important for coping with first generation problems while public and private decisions are closely relevant to the second and later generation problems. (14, pp. 1–2) There are many challenges requiring public decisions by developing countries. But two in particular appear to me to be of overriding importance to their agriculture:

Relating food production to world trade.

Expanding employment to meet population increases.

## RELATING FOOD PRODUCTION TO WORLD TRADE

The major problem of the 1960's was to increase production to meet immediate demand. Recent breakthroughs in production now make it possible for some countries to realistically consider cereal production policies in the 1970's in light of questions such as: How much food should they import or export? How quickly can they afford to adopt aggressive policies to correct inadequacies of nutrition? In short, these countries face the need to adjust production in line with a host of factors. These include four which have special relevance to gauging the balance between production and trade. They are (1) increased world supplies of wheat and rice, (2) excess capacity in developed countries, (3) comparative advantage and prices, and (4) potentials for diversification such as livestock production.

### *Increased World Supplies of Wheat and Rice*

Production increased in both the developed and the developing countries in the 1960's. For example, 1968 cereal production in each group of nations increased 25 and 20 percent respectively above the 1960–64 average. (Table 3) But while the developed countries increased cereal output by 120 million tons, the developing countries, with twice as many people, increased cereal production only 50 million tons. As a result, per capita cereal production in the developed countries increased 17 percent while in the developing countries 1968 per capita production merely recovered to the level of the early 1960's—an amount less than half as much as in the developed countries.

TABLE 3.—GRAIN PRODUCTION WORLD [1], 1960–68

| Area | 1960–64 average | 1967 | 1968 | Change 1960–64 to 1968 | | Change 1967 to 1968 | |
|---|---|---|---|---|---|---|---|
| | Million metric tons | | | Tons | Percent [2] | Tons | Percent |
| Total production: | | | | | | | |
| Developed countries | 485 | 585 | 608 | +123 | +25 | +22 | +4 |
| Developing countries | 283 | 325 | 335 | +52 | +18 | +10 | +3 |
| Wheat | 45 | 51 | 59 | +14 | +31 | +8 | +16 |
| Rice (paddy) | 138 | 155 | 156 | +18 | +14 | +1 | +1 |
| Corn | 47 | 61 | 61 | +15 | +32 | 0 | 0 |
| Other [3] | 53 | 58 | 59 | +6 | +10 | +1 | +2 |
| World | 768 | 911 | 943 | +175 | +23 | +32 | +4 |
| Per capita production: | | | | | | | |
| Developed countries | [4] 494 | [4] 564 | [4] 580 | [4] +86 | [5] +17 | [4] +16 | [5] +3 |
| Developing countries | [4] 206 | [4] 210 | [4] 210 | [4] +4 | [5] +2 | | |
| World | [4] 326 | [4] 351 | [4] 357 | [5] +31 | [5] +10 | [5] +6 | [5] +2 |

[1] Excludes Communist Asia and Cuba.
[2] Calculated from unrounded numbers
[3] Includes millet, sorghum, rye, barley, oats, and miscellaneous.
[4] Kilograms.
[5] Percent

Source: Economic Research Service. Compiled from data provided by Charles Gibbons.

The increases in the developed countries included such outstanding changes as a 75 percent increase in Australian wheat production from the 1960–64 average to 1968 and nearly a 70 percent increase in U.S. rice production.

Developments in the international wheat and rice markets illustrate their different competitive nature

World wheat exports for 1968–69, for example, are estimated at 1.8 billion bushels, 10 percent below 1967–68 levels and almost 25 percent below the peak in 1965–66, when poor weather in Communist countries and drought on the Asian

subcontinent increased import requirements. (Table 4) Exports to the Communist countries, as well as India and Pakistan, are only slightly different from the early 1960's but approximately 20 percent below the 1960-61 to 1964-65 averages.

TABLE 4.—WHEAT EXPORTS, WORLD, 1960-61 TO 1968-69

| Destination | In million metric tons | | | In percent | |
|---|---|---|---|---|---|
| | 1960-61 to 1962-63 (average) | 1960-61 to 1964-65 (average) | 1968-69 | Change from 1960-62 to 1968 | Change from 1960-64 to 1968 |
| Communist countries | 9.2 | 11.9 | 9 8 | −6.5 | −16.6 |
| India and Pakistan | 4.7 | 5.8 | 4.5 | −4.3 | −22.4 |
| Other | 30 9 | 30.6 | 33.5 | +8.4 | +9.5 |
| World total | 44 9 | 48.3 | 47.8 | +6.5 | −1.0 |

Source: Calculated from data in Foreign Agriculture, May 26, 1969. Converted from bushels on the basis of 1 metric ton equals 36.74 bushels.

Prices of most wheat entering international trade have declined only modestly while stocks in the major exporting countries have increased to about the levels of the early 1960's[5] In contrast, rice prices have dropped sharply from their highs in early 1968 to 1966 price levels.

Thus, the green revolution in the developing countries is gaining momentum at the same time that (1) cereal supplies are increasing in developed countries, (2) wheat trade is declining to levels of the early 1960's, (3) wheat stocks are expanding, and (4) world rice prices are dropping to levels of the mid-1960's Consequently, it is not surprising that there is much talk of world grain surpluses and concern about the effect of increased production in the developing countries on world markets.

*Excess Capacity in Developed Countries*

One of the principal facts of life confronting developing countries is the excess agricultural capacity of the developed countries at prevailing prices.

We are all acquainted with the productive capacity of U.S. agriculture This past year almost 50 million acres were withheld from farm production in an effort to balance output and demand.

Western Europe is dominated by policies of the European Community and the prospective membership of the United Kingdom which has followed a persistent policy of increased self-sufficiency. (22) Grain prices of the European Community are in many cases double the prices in international markets and export subsidies are so large that they undercut prices of other exporters as distant from Europe as Taiwan. This year the countries of the European Community are spending nearly $1 billion for handling dairy surpluses alone and an estimated total of over $7 billion to support their agricultural programs.[6]

Japan is also highly protectionistic in some areas. Producer prices for rice are over $18 per hundredweight. Beef imports are severely limited.

The export markets will continue for many years to be influenced by this excess capacity. Thus reductions in import requirements, as well as export efforts of developing countries, will be sensitive issues of international trade and development.

*Comparative Advantage and Prices*

In the mid-1960's, many developing countries gave little attention to the principle of comparative advantage and the nature of international markets in their pursuit of increased production. This seemed logical. The Asian subcontinent had had a severe drought, nutritional needs were great, many countries were heavily dependent on concessional food, and budgets and balance of payment problems were substantial restraints on ability to import.

[5] Average October 1968–March 1969 export prices for U.S. No. 2 hard winter were down 4.4 percent from the average in the comparable six month period of 1966–67. And No 2 Manitoba had dropped by 7.2 percent. French wheat export prices have dropped much more, reflecting the aggressive export subsidizing programs and policies of the European Community, and their unwillingness to restrict production or build up substantial stocks to assist in maintaining prices in international markets.

[6] These figures are based on special calculations made by the Foreign Development and Trade Division, ERS, USDA.

Yet, as agricultural changes spread, problems relating to comparative advantage and international markets will be anything but academic. The success of earlier policies in many countries brings them into direct confrontation with problems of the world market place. Countries, in allocating their scarce resources, must confront such questions as: Which of their farm products are most competitive in the world market? In which products is there the least competitive disadvantage when returns for all are low? What is the competitive position of their country's resources for industrial production? And, how does protectionism in Europe and Japan, and import policies of the Communist countries, as well as North America, on unprocessed as well as processed farm products, affect their competitive position?

Consideration of these and similar questions must take into account prospective technology. One of the underlying objectives of economic growth is the development of resources and technology so that latent comparative advantages can, in fact, be realized.

The developing countries have traditionally exported large amounts of tropical products. However, I think that it will be economically difficult for them to become substantial grain exporters in the near term. It is much easier to increase production for indigenous consumption than for export. Often the domestic market is more tolerant of variable quality than are the export markets. Further, when a country depends partially on imports, its farmers are essentially competing against import prices which reflect delivered costs from surplus-producing countries. On the other hand, when a country produces more than its domestic needs, farmers get much lower prices because the extra costs of exporting their product to third countries must then be taken into account. The difference between these two sets of farm returns may be as much as $25 to $32 per ton.

Admittedly, subsidies and tariff policies can distort these relationships. But in most developing countries, the resources available for such policies are extremely small, especially in relation to similar expenditures in developed countries.

Many countries, developed as well as developing, support domestic prices above world prices and therefore compound problems of rationalizing trade and production. Support prices vary widely. (Tables 5 and 6) But these relationships depend partly on whether free or fixed exchange rates are used for international comparison. For example, in Turkey, producer returns for wheat are $87 per ton when calculated by the fixed rate, but $59 per ton with the free rate. For current price comparisons, those rates actually used for cereal and fertilizer trade are most appropriate. But in terms of the longer run economic development and competitive position in international markets, the free rates in the developing countries may become increasingly relevant as currencies are devalued.

TABLE 5.—GOVERNMENT SUPPORT OR PURCHASE PRICES: WHEAT AND CORN, SELECTED COUNTRIES, 1968—AT OFFICIAL AND FREE RATES OF EXCHANGE

[Dollars per metric ton]

| Wheat | | | Corn | | |
|---|---|---|---|---|---|
| | Exchange rate | | | Exchange rate | |
| Country | Official | Free | Country | Official | Free |
| Mexico | [1] 64 | ---- | Mexico | [3] 75 | ---- |
| Brazil | 88 | ---- | Brazil | 47 | ---- |
| Colombia | 126 | 116 | Kenya | 43 | 34 |
| Paraguay | 80 | 78 | Thailand | 47 | ---- |
| Morocco | 79 | 71 | United States | [4] 50 | ---- |
| Turkey | 87 | 59 | | | |
| Pakistan | 96 | 53 | | | |
| India | 101 | 72 | | | |
| United States | [2] 97 | ---- | | | |

[1] Major producing states of Sonora, Sinaloa, and Baja, Calif. Elsewhere, $73.
[2] Loan rate ($46) plus certificate ($51)
[3] Unirrigated area; $64/ton in irrigated area.
[4] Loan price ($39) plus support payment ($11).

Source: Reference 8. Exchange rates published in Picks Currency Yearbook, 1968.

TABLE 6.—GOVERNMENT SUPPORT OR PURCHASE PRICES: RICE, SELECTED COUNTRIES, 1968—AT OFFICIAL AND FREE RATES OF EXCHANGE

[Dollars per metric ton]

| Paddy rice | | | Milled rice | | |
|---|---|---|---|---|---|
| | Exchange rate | | | Exchange rate | |
| Country | Official | Free | Country | Official | Free |
| Burma | 36 | 13 | India [1] | 96 | 68 |
| India [2] | 56 | 41 | Pakistan (West) [3] | 107 | 59 |
| Philippines [4] | 93 | 88 | Japan [5] | 420 | 392 |
| Brazil | 79 | ---- | | | |
| Ecuador | 123 | 105 | | | |
| Senegal | 85 | (6) | | | |
| Japan [5] | 294 | 274 | | | |
| United States [7] | 100 | ---- | | | |

[1] Average of procurement prices for rice (Rs. 72/quintal).
[2] Support price for paddy (Rs. 42–44 maund). No recent Government purchase because market prices are well above this level.
[3] Announced procurement price for coarse rice paid to mills (Rs. 19/md). Actual price paid to farmers for paddy was about half of this (Rs. 7–11/md).
[4] Government funds were insufficient to purchase all paddy offered for sale at this price.
[5] Official support price is for brown rice Converted here to paddy and milled equivalent.
[6] Not available.
[7] Loan price. (Average price received by farmers was $110.)

Source: Compiled by Dana Dalrymple from various reports issued by the Foreign Agricultural Service and the Agency for International Development Exchange rates published in Picks Currency Yearbook, 1968.

Mexico, a country with outstanding success in increasing wheat and corn production, illustrates the type of adjustments that will be pressing many developing countries. New technology in the form of the dwarf wheats shifted the Mexican wheat supply function sharply to the right. Prices above world market prices, combined with the new technology, made Mexico a "surplus" wheat country relative to domestic demand. Then, the Mexican Government lowered prices to reduce production. The 1968–69 wheat acreage decreased but increased yields offset most of this decline. Wheat is being purchased by CONASUPO (the government trade agency) at $64 and $73 per ton, prices almost 50 percent above those currently obtainable by Mexico in international markets. An even more severe price relation exists for corn. (8) (20)

*Livestock—One Possible Adjustment*

Shifting land from cereals to other crops is one way in which countries can adjust their production. (6) Perhaps an even more important aspect of diversification, however, will be increased livestock production. This will be especially relevant for medium income countries approaching self-sufficiency in cereals. (17) Livestock production has an important role as a balancer between cereal requirements and supplies Where little grain is fed to livestock, demand for cereals is often extremely price inelastic and changes in production have very sharp effects on prices.

Livestock can also be important in cushioning the effects of cereal production changes. For example, when production is short, diverting cereals from livestock to human consumption, and slaughtering of livestock, can mitigate demands on foreign exchange and decreases in total caloric supply. Alternatively, when cereal supplies are large, increased consumption of cereals by livestock can absorb higher production and thereby mitigate pressures upon the marketing systems to move cereals, perhaps even into export channels.[7] In addition to this balancing role between requirements and supplies, livestock production can make important contributions to the economy in absorbing labor, increasing economic activity, and perhaps earning foreign exchange.

*The Balance*

It is impossible to anticipate how the developing countries will react to these many forces and, in turn, relate their production to international trade. For example, exports of any one developing country that has been importing is not

[7] Paarlberg points out that this and several other adjusters are the reasons why collision course projections are too simplistic and that there is "an enormous capacity for adjusting the use of agricultural resources and the food intake." (19, pp 41–45)

likely to be large enough to significantly affect world market prices; in effect, these countries will confront essentially a perfectly elastic export demand function. However, because of poor quality, small volume, and lack of market experience, prices they receive may be substantially below that received by more traditional exporters.

Liberalization of trade will probably not be sufficient to increase world prices, nor substantially increase grain imports by developed countries Trade policies remain oriented to domestic interests and it is not likely that countries such as Canada, the United States, and the developing countries will forge an alliance which will effectively pressure the European Community, Japan, or Communist countries to adjust agricultural domestic and trade policies.

Supply in many countries will continue to be profoundly influenced by the new technologies of dwarf rice and wheat, as well as weather. The rate of expansion of high-yielding varieties will gradually diminish, however, as the present areas with controlled water supply become more fully planted.

At the same time, popuation growth rates continue to be high and will lead to substantial increases in cereal requirements. India, for example, to simply maintain per capita consumption must increase cereal production by almost three million tons a year. Further, nutrition improvements will depend greatly on increased incomes. Hopefully the developing countires will be able to translate the recent agricultural changes into more general economic growth. Their ability in accomplishing this objective will have an important bearing upon their import needs

On balance, the many forces in world markets, as well as in the developing countries suggest that these countries will not find it practical to base their development plans on grain exports Some countries, of course, may move into a surplus situation and they will invariably consider exporting at least on a temporary basis.

### EXPANDING EMPLOYMENT TO MEET POPULATION INCREASES

Tremendous problems confront leaders of developing countries in coping with increased rural, as well as urban, populations. These problems will often take the form of growing underemployment and unemployment in rural areas.

An indication of growing employment requirements is the projection that the 1985 farm population of the developing countries will be 40 percent above the 1962 level, even though the farm population, as a proportion of the total, is expected to decrease from 65 to 53 percent. (1, p. 6) In terms of India, Nair estimates that the number of workers in agriculture will reach 190 million by 1975 compared to 170 million expected in 1970. (18) These prospective increases in the labor force reflect the sharp reduction in death rates, especially among children, experienced in the 1950's.

The problem of labor absorption in agriculture is compounded by the disappointing growth of industry. India, for example, anticipated in the 1960's that unemployment would increase even with expansion of industrial jobs much higher than have been realized. Therefore, unless industrial growth can somehow be accelerated dramatically, the creation of jobs in agriculture will be of utmost importance to the labor absorption problems of the developing countries.

Because of the limited growth in food production, aggressive policies to increase employment have been haunted by the risks of inflating food prices Now with the availability of the high-yielding varieties, the prospects for sustained improvements in food production are improved. Thus, these countries can pursue policies and programs to expand employment with much more confidence that the ultimate effect will not be undue inflation but rather improved nutrition and welfare brought about by the increased demand met by expanded food supplies.

The burden of unemployment will likely fall on those who are already poor and further exacerbate the income distribution problems that are increasingly evident For example, many rural people have been bypassed by the benefit of high-yielding varieties. Those in regions without irrigation water have generally not benefited.

Further, increased incomes have not generally been passed on to labor, although the new varieties have often resulted in increased wages during periods of peak labor requirements, such as harvesting. Johnson writes "So far there has been little sharing of the benefits from intensive agriculture with the landless laborers. They are the most neglected group in rural society." (15, p. 14)

In the Tanjore District of Tamil Nadu State in Southern India—an area of exceptional progress in rice production—a serious conflict recently broke out between landlord and laborers over wages. (5) These income distribution problems among regions, and among groups within regions, are bound to become increasingly sensitive, especially if the number of new jobs does not keep pace with the number of available workers.

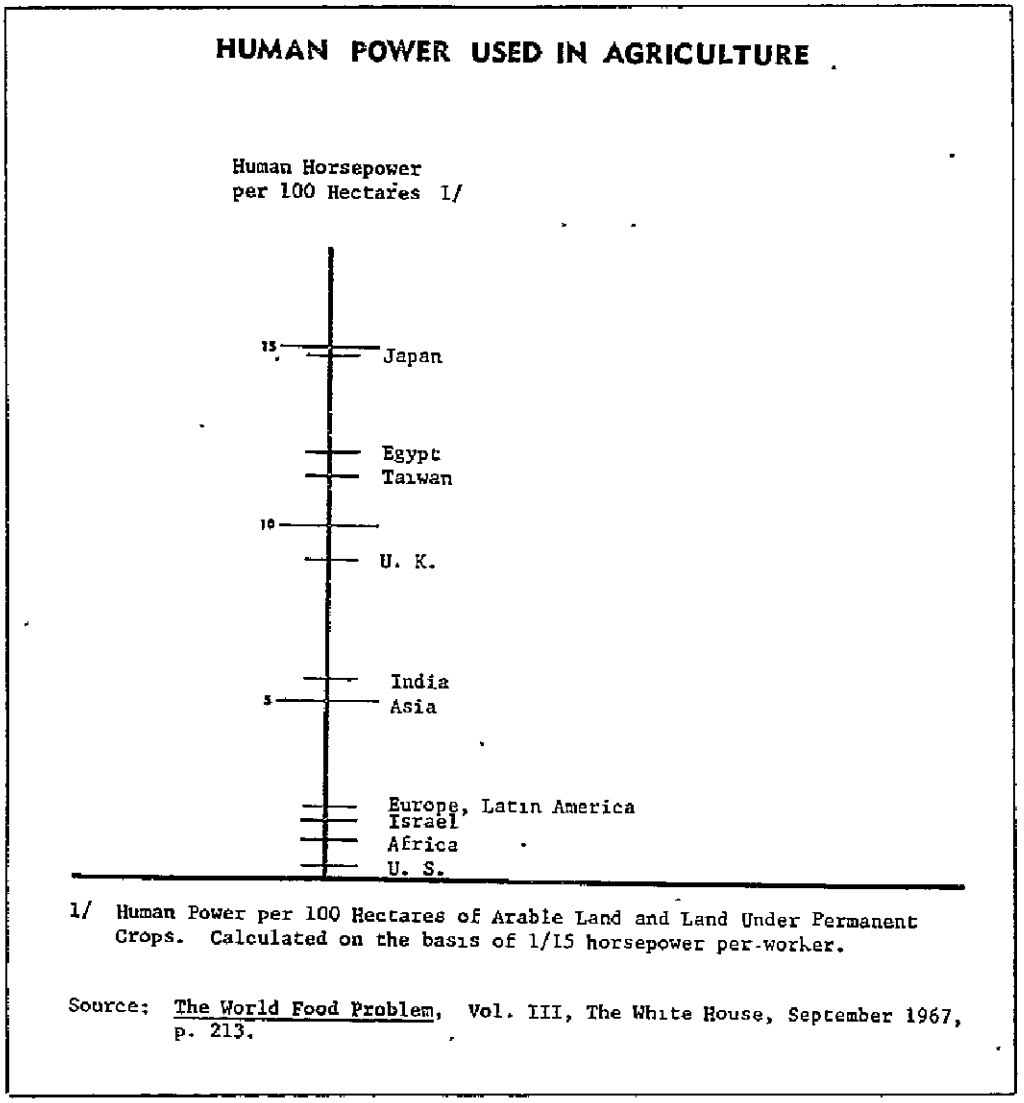
Therefore, crucial questions involve the extent to which policies can be shaped to maximize employment while still meeting production objectives. Particularly important are strategies relating to mechanization, irrigation, and agribusiness.

*Mechanization and Irrigation*

The direct effect of most increases in mechanization is the displacement of labor However, consideration of only direct effects can lead to erroneous conclusions For example, the high-yielding rices mature in four instead of six months and therefore permit growing a second crop. But often this potential can't be realized unless the ripened crops can be harvested quickly and the land prepared immediately for the following crop. This often requires mechanization. Some labor may be displaced in harvesting or soil preparation, but growing the second crop can lead to substantial increases of total labor requirements through the year.

Investing in machinery, substantially above the levels that generally prevail in the developing countries, is not necessarily inconsistent with large inputs of labor. Human labor in Japan, Taiwan, and Egypt supply much more horsepower per hectare than in India and in Asia as a whole. (Figure 3) But all three countries also have much more investment in machinery than other developing countries. Japan's per acre investments in machinery are among the highest in the world. The high ratio of human horsepower per acre in these countries is substantially accounted for by the widespread irrigation systems along with mechanization requiring large complementary inputs of labor.

FIGURE 3




1/ Human Power per 100 Hectares of Arable Land and Land Under Permanent Crops. Calculated on the basis of 1/15 horsepower per-worker.

Source: The World Food Problem, Vol. III, The White House, September 1967, p. 213.

These possibilities point up the need to look at questions of developing agriculture in a dynamic framework. When considering mechanization we should not just study the effect of increased agricultural machinery with no changes in other inputs and or in technology. Other inputs, as well as technology, will change and nonfarm employment in related industries (equipment, parts, supplies and repairs) will increase.

Thus, we must consider the potential effect of mechanization on labor requirements in terms of alternative farming systems. One system to consider is the widespread growing of high-yielding varieties on a substantially increased area of irrigated land. This approach may be the best hope in expanding labor requirements in agriculture.

Farmers are apparently very interested in more irrigation; adequately controlled water is necessary to realize the yield potential of the new varieties. For example, farmers in West Pakistan installed 2,400 tubewells during 1967/68 and are expected to install some 7,000 during 1968/69. In India, the number of tubewells, both private and state, is increasing at an annual rate of 41,000 per year. These are supplementing water supplies

on irrigated acreage and also increasing the irrigated area by about 2.2 million acres per year. Electric pumps are being installed at an estimated annual rate of 140,000 per year. (28) Thus, one of the significant payoffs of the high-yielding varieties may be increased labor needs in expanded irrigated projects.

*Agribusiness*

Development of agribusiness will also influence employment. In the United States, for example, total agribusiness employment has declined only slightly despite the rapid movement off our farms. Numbers of farm workers in the United States dropped 50 percent between 1957 and 1966, but nonfarm agribusiness employment increased 22 percent and total agribusiness employment—including farm workers—decreased only five percent. (24)

The U.S. experience is with capital-intensive enterprises that the developing countries should not generally try to emulate. On the other hand, agribusiness can be developed with labor intensities much higher than in the United States.

Marketing deficiencies in less developed nations take many forms. The present physical facilities, particularly for storage and transportation, simply cannot move needed inputs to farms and increased farm output to markets efficiently. Costs are high and physical losses great. Marketing information, grades, and standards are seriously lacking. (16)

Increased production leads to larger relative increases in marketings and perhaps a greater concentration of marketings shortly after harvest. Barker estimates, that of the increased rice production on surveyed farms planting new varieties in the Philippines, 80 percent was marketed and only 20 percent was cousumed in the home. (2) (3)

In addition to facilities for drying, grading, processing, and transporting products to consumers, modern agriculture requires a vast array of inputs—pesticides, credit, tools and machinery, seed, and fertilizer. Providing these can substantially increase employment opportunities.

*Many Questions Remain*

Much research is needed on the employment-population problem; frankly we don't know answers to many of these challenges. Much more attention must be given to alternative approaches; questions such as the following need answers:

What are the trade-offs among different farming systems on food production, employment, and economic growth?

What are the effects of different types of irrigation projects on the same variables?

What are the relationships between mechanization and labor in different production enterprises? Where are they competitive? Where complementary?

To what extent can public works in rural areas affect employment?

How will policies to increase rural employment affect other problems such as urban health, sanitation, and housing?

Can research and extension programs be shaped to develop and spread labor intensive technologies in agriculture?

## CONCLUDING REMARKS

The problems of (1) relating production and trade, and (2) expanding employment present great difficulties. But in a larger sense they are challenges for both the developing and the developed world to bring about fundamental and lasting changes for the benefit of humanity.

The effective rationalization of production and trade will be trying and complex. Problems of excess capacity of world markets, domestic prices sharply different from international prices, and artificial exchange rates will make the tasks of the 1970's much more complex than those which have been overcome in stimulating production. The expansion of employment is equally challenging for the spectre of millions unemployed threatens to negate all efforts to improve economic welfare of these countries.

Perhaps the greatest challenge in meeting these problems will be to fuel the agricultural revolution so that it can be effectively translated in general economic growth. Such growth will ease the problems of relating production and trade, as well as the expanding employment. Thus the green revolution can and should be viewed as a base for further progress.

How the developing countries respond to these challenges and how the developed countries assist in that response will, in fact, determine if the momentum of agricultural change will be extended into the 1970's or if it will falter. The outcome will depend on what we do or fail to do in the next few critical years. Hopefully the recent breakthroughs will not cloud our awareness of the challenges of the 1970's so that, in fact, the green revolution is the beginning of a series of developments leading to better nutrition, expanded economic growth, and more equitable distribution of income.

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## Spring Review of the New Cereal Varieties Implications for AID

*(A report by the Agency for International Development, June 1969)*

### INTRODUCTION

The Review of the high-yielding cereal varieties was directed at two questions—

1. What lessons can be learned for improving specific A.I.D. activities in agriculture?
2. What conclusions can be drawn concerning the relative emphasis among activities in A.I.D.'s future agricultural strategy?

The present paper attempts to summarize the conclusions of the Review relevant to these questions. The sections which follow contain a general statement of proposed A.I.D. agricultural strategy (Section I) and the findings and recommendations on the major topics covered by the conference (Sections II–VII). For each of the topics covered, the essential background and agreed facts are sketched under the heading FINDINGS; a second part states IMPLICATIONS FOR A.I.D.

Although the Review focused on the high-yielding varieties (HYV) of rice, wheat, and corn; the discussion was wide-ranging and frequently extended into general problems of agricultural development. Moreover, some of the matters discussed involved sensitive political issues for the recipient countries. No material is excluded from this summary because of either of these considerations.

To facilitate consideration of the document, the implications for A.I.D. which have the most immediate significance either for operations or for prompt study are marked by an asterisk.

### I. SUMMARY AND OVERVIEW

1. The notable success in increased grain production in the past couple of years demonstrates what can be accomplished in LDC agriculture. Agriculture continues to merit top priority in most developing countries. The successes in foodgrains, however, call for some shift in emphasis in A.I.D.'s agricultural programs.

2. The "agricultural revolution" has been concentrated essentially in spring wheat and rice, principally in the countries of East and South Asia, and confined almost entirely to areas with ample water supply. Without minimizing in any way an accomplishment which has completely transformed the food prospects of most of the important food deficit countries, A.I.D. must take account of these facts, and of the further fact that even in the countries most benefited, the "revolution" has directly touched only a minority of the farming population. Nevertheless, in breaking the mold of traditional agriculture and demonstrating the results that can follow the introduction of new technology, it has opened the way to further change. A.I.D. must seek to capitalize on the new opportunities for agricultural growth which now exist.

3. Experience with the introduction and diffusion of the new cereal varieties has demonstrated that constraints on agricultural growth are fewer and more readily overcome than previously assumed. This experience indicates that assuming a minimum basic infrastructure the essentials for a marked acceleration in agricultural growth are: (a) a new technology which offers the possibility of a significant increase in profits (i.e., reductions in costs per unit of output), (b) the capacity with or without outside assistance to adapt this technology to local conditions, (c) commitment to a campaign of expanded production at top levels of the government, (d) a cadre of skilled personnel in the agricultural sector which, either inside or outside existing institutions, can be aligned in a campaign structure. Most of these elements may be present in some degree in a given country with little effect on production. In this case, supplying or strengthening the deficient component(s) may produce a sharp rise in output.

4. The Review considered a range of topics—price policy, management systems, institutions, physical inputs, research, and emerging problems—related to the introduction and diffusion of the new cereal varieties. The findings on each of these topics, and their implication for A.I.D., are treated in the following Sections of this paper.

5. Summing up the state of affairs in the spring of 1969, it can be said that agricultural growth in the most populous of the LDCs has reached the point where famine is no longer an imminent threat; where in some countries self-sufficiency in cereals production is already in sight; and where a number of new adjustments will be called for.

6. In considering the problems of the future, it is desirable to begin with the lessons learned from experience with the HYVs. A few basic points emerge as central. These are summarized below:

a. The ability of a well-conducted crop campaign, based on a new and productive technology, to activate important parts of the agricultural sector, and to mobilize the public and private support necessary to its success.

b. The increasing need for wise government policy, as cereals campaigns approach their goals. The HYVs seemed to provide a providential means for escaping the ominous threat of famine and they were seized on eagerly, and utilized without much advance planning. The problems of the future will require more careful study.

c. The need for a continning flow of technological innovations, produced by research.

d. The need for an expanding body of trained manpower, on which effective policy planning, research and institutional operations will depend.

e. The need for institutions, capable of helping the disadvantaged farmers, who, for want of knowledge, good land, water or financial resources, are unable to respond quickly to new technologies.

These points are developed somewhat more fully in the paragraphs which follow:

7. In almost all countries considered, the HYV rice and wheat proved to be a powerful innovative force which compelled a change in traditional agriculture. They brought new life to moribund institutions—co-operative, private enterprise and governmental—and stimulated the development of ad hoc arrangements where existing institutions were unable to meet felt needs. The single crop campaign has proved a singularly effective way to "get agriculture moving." The success of these campaigns suggests the desirability when the opportunity and basic requisites are present, of a country focusing efforts on a specific sector of the agricultural economy.

8. The HYVP is an effective way to introduce an element of dynamism in the agricultural sector. Once this element is present, it begins to generate new problems, and makes even more urgent the development of a coherent strategy for rural development, geared to the country's own requirements and potential. Few LDCs have such a strategy, or, indeed, are capable of producing one. For this type of planning requires competent agricultural economists, and such personnel

is in short supply among LDCs. A.I.D. itself is inadequately staffed in this area, and most Missions are unable to provide first-class planning assistance in the agricultural sector. The Agency needs to strengthen its own competence in this field and to make better use of the skills of the U.S. universities and other institutions to provide aid to countries which need and want it. The ultimate objective, of course, must be to strengthen the competence of the LDC to do its own agricultural planning.

9. Recent agricultural growth in the LDCs covered in this review has been generated by new and profitable technologies of cereals production. These technologies were the product of a chain of scientific research: the beginnings were in the institutions and the scientific techniques perfected in the developed countries; the critical transformations occurred in two international research institutes which mobilized interdisciplinary staffs of high competence, assembled banks of genetic materials, and used advanced techniques to produce varieties suitable to the tropics and sub-tropics; the final phase was the testing and adapting of these new varieties under specific local conditions in the individual LDCs. Continuing progress in LDC agriculture will require a continuing flow of technological innovations, much of which, it may be assumed, will be developed through similar processes. A.I.D. needs a clearer overview of the research needs of the developing countries, of the various institutions which are now helping, or could help, to meet these needs. It also needs a clearer concept of the kind of system which will most effectively discharge the dual task of furnishing research products needed by the LDCs in the near term, and strengthening the capacity of the LDCs to do the job for themselves.

10. The performance of the many skilled functions needed for further agricultural development will require an expanding base of skilled manpower in the LDCs. As experience with the new cereal varieties demonstrates, some of the technology can be imported, and the skills essential to a single crop campaign can be developed by overseas training. Ultimately, however, the success of A.I.D.'s programs in the agricultural sector will depend on the degree to which they produce within the LDCs the capability to organize, staff, and administer their own institutions.

11. The Review revealed that with the powerful stimulus of the new cereal varieties, it was possible to improvise a structure to perform the functions essential to their introduction and diffusion. It cannot be assumed that this pattern will be repeated when the more complex second generation problems demand attention. The need for an institutional structure, which includes at least rural education, extension, credit and marketing, is foreseen.

12. Proposals for A.I.D. programs made in this paper of course assume that LDC Governments and important elements of the population want agricultural growth and the improvement of rural life. With such a Government and people to cooperate with, it should be possible for A.I.D., working with other aid-giving countries and institutions, to do much to accelerate the agricultural revolution, and to extend its benefits to larger parts of the population. The capacity to produce technological innovations exists; the techniques for successful crop campaigns have been mastered; means for vitalizing moribund agricultural institutions and enlisting farmer participation in co-operative enterprises have been found. With these assets, Governments can move to a position where it becomes feasible to adopt policies which expand employment, strengthen rural infrastructure, benefit increasing number of farmers, and contribute to overall economic growth. This is the potential of the green revolution; A.I.D.'s objective in the period ahead must be to help the LDCs realize it.

## II. PRICE POLICY

*A. Findings*

The HYV experience has revealed a number of the characteristics of farmer response to prices, risk and certainty. That the so-called traditional farmer's presumed high aversion to risk can be overcome by high profitability, has been amply and even dramatically demonstrated.

The technological quantum jump in profitability, under suitable conditions, was the most significant factor in the adoption and diffusion of the new seeds. The differences between wheat (or irrigated or in assured rainfall areas) and rice illustrate this point. The differenetial success with the new rices in favorable as contrasted with less favorable areas does also. Conditions of relative cereal

scarcity in most of the countries considered reinforced the technological shift in profitability, and provided further assurance of high market prices.

Governments, often on A.I.D. urging or with A.I.D. acquiescence, adopted other measures to influence relative profitability. By and large, these direct governmental price interventions—input subsidization and output price support—have been less significant than the basic profitability of new seeds in the diffusion of HYV's That is, rapid adoption of new responsive varieties has occured both with and without input subsidies, and under varying types and amounts of output price support.

Although the record indicates that input subsidies (or fertilizer, pesticides, credit, water, electricity) were widely used, they were generally thought to be undesirable by participants in the Review. Support for input subsidization was largely confined to early subsidies for fertilizer for two limited purposes: to accelerate the initial adoption of new varieties or practices and to hasten the reaching of an economic scale of production and distribution from new indigenous fertilizer plants. Renewal of such temporary subsidies was strongly advocated as soon as the initial purposes were served and before political pressures for their maintenance became too strong The only justification suggested for continuation of input subsidies was that they might be used to provide preferential treatment for low income or disadvantaged farmers if the administrative problems of differential programming could be surmounted.

The record of experience with output price support is less clear as are the conclusions to be adduced from it. There was recognition that high, permanent output price supports might, while increasing production of the supported crop, merely shift acreage or inputs from other crops, not necessarily producing advantage or resulting in an increase in total agricultural output or income. It was also recognized that continuing output price supports above world market prices were undesirable.

A strong case was made that output price supports which might have undesirable side effects when used as an *incentive* for one or several crops, could provide desirable *insurance* against the risk of a deep price drop consequent on a sharp rise in production. (There was not much analysis in the crop papers, nor discussion at the Review, of the corollary role of stocks acquired under price support programs when production was high as a buffer against subsequent low production).

The use of output price supports for stabilization purposes was recognized as a valid and probably necessary way to avoid wide uncertainty regarding future market prices, thus eliminating or tempering one of the major risks the farm entrepreneur faces. While majority opinion supported this view and its concommitant moderate ("not high") price support policy, there was no consensus on whether the support price needed to be established before planting (as A.I.D. has usually esponsed for "incentive" purposes) or merely before harvest.

The trade-offs are: farmer uncertainty of harvest prices if support prices are not announced early, versus allowance for "some" decline in market prices if a good yield is secured. The advantages of lessening farmer uncertainty are obvious The advantages of permitting a moderate decline in market prices are: avoidance of undue burden on the public budget and the allowance for controlled secular declines in price if productivity continues to rise. One country crop experience (India-wheat) demonstrates an effort to do both; a low support price (still profitable with HYVs) was announced pre-planting, and a higher procurement price—supporting the market—has been announced just before harvest.

While price stabilization policies were generally considered necessary, and "incentive" prices possible justified in some cases and for limited periods, it was recognized that any system of price support involves an administrative burden. It was further recognized that less developed countries characteristically lack highly developed administrative systems.

*B. Implications for A.I.D.*

The powerful consequences of technological advance on farmer incentives, and the implications for research are discussed in VI. below. Other guidance for A.I.D. which emerged is that:

1. A.I.D. should not in general sponsor or support input subsidies except where they are clearly needed as inducements and are clearly temporary, or (perhaps) if they can be so structured as to have a positive effect on disadvantaged farmers or areas.

2. A.I.D. should in general advise against high, continuing output price supports, except where their allocative effects (shifts in acreage or in input use) have been analyzed and found clearly desirable, and the administrative problem tolerable.

*3 A.I.D. should sponsor the development of tailored price support policies and organizations which will provide advance assurance (either by advance announcement or by earned confidence in governmental policies) against sharp price drops, while permitting relatively smooth secular price adjustments in tandem with productivity changes.

4. A.I.D., clearly, will need to take account of the administrative competence of the Govenment in considering the practical measures the country concerned should be advised to adopt to give effect to these objectives.

*5 A.I.D. must increase its in-house capability and the outside competence available to it on contract to analyze the complex of economic, political, and administrative factors involved in the above recommendations so that the Agency's ability to advise, correctly and persuasively, is enhanced.

## III. MANAGEMENT SYSTEMS

### *A. Findings*

All the HYV countries covered in the Review mobilized exceptional teams of men and institutions to carry out crop campaigns. In India and Pakistan, two or more crop campaigns were organized without significant A.I.D. administrative participation and carried on simultaneously. In Turkey, Vietnam, and the Philippines single crop campaigns were designed and implemented with A.I.D. assistance The activating force behind all of these campaigns was a firm resolve by the Government to clear traditional bureaucratic hurdles and make the necessary administrative and financial commitment to reach the target. The Missions report that such support was essential to successful propagation of the HYV programs. It is noteworthy that wherever this support from top Government leaders was provided, its effects were strong and positive. Further, political benefits to the LDC Government frequently accompanied the increased harvest

Most of these crop campaigns had some quantitative goals—total production to be achieved or total acreage to be covered. They all focused on relatively limited areas of high potential productivity. They all made an effort to provide individual farmers with the information necessary to grow the crop successfully. There was, in all cases, an adequate incentive to the farmer—in terms of the balance of input/output prices—to energize him to participate actively in the campaign. Where these elements were present, an extraordinarily rapid diffusion of the new varieties took place.

In at least two countries—Turkey and Vietnam—a more systematic effort was made to schedule the provision of key inputs of technical information and material on a precisely calculated time-phased basis. In Vietnam a full-fledged PERT system was developed during the second crop season to provide better control over the IR–8 rice production program. USAID officials insist that these advanced programming and implementation systems improved the Government's control over the crop campaign and contributed to its success. Their arguments are persuasive, although there is no quantitative means to measure the contribution and seemingly comparable successes occurred in other countries employing less elaborate techniques.

Any system, of course, must be built on the already existing institutional structure, and should reflect the judgment of those who know the strengths and weaknesses of the institutions involved. The effective implementation of crop campaigns and advanced scheduling systems would appear to depend upon the availability of a number of factors which some of the less advanced countries do not possess. The prerequisites include (1) a reserve of skilled personnel to draw on, (2) an institutional base sufficiently articulated yet flexible to be galvanized into a national campaign, (3) input/output price relationships which made adoption of the new crop technology an attractive proposition for the farmer, including administrative action to minimize the risk of price declines resulting from a rapid increase in output and (4) a firm commitment to a campaign at the highest level of government. Where these prerequisites are satisfied, A.I.D. has demonstrated the ability to effectively supply the missing management technology to support the initial takeoff. In these circumstances, crop campaigns may be a highly useful instrument and serve to energize the entire agricultural sec-

tor. But the ultimate decision to institute such a campaign depends of course on the economic argument for rapid boosts in production of the target crop.

*B. Implications for A.I.D.*

*1. The principles and techniques of crop campaigns should be more systematically studied by A.I.D., and the methodologies suitable to countries of different levels of administrative competence should be defined Additional personnel should be trained in these techniques, and the provision of consultants may be called for. Professional training in agriculture is not indispensable for the top leadership in the effective management of crop campaigns.

*2 A.I.D. should encourage crop production campaigns in food deficit countries where the necessary pre-conditions described above exist, where rapid increases in the single crop would have high returns and would support the general development program, and particularly where such a campaign seems likely to energize other parts of the agricultural sector.

3. A.I.D. should encourage the LDC to adopt the advanced programming systems only if the Government has the degree of administrative sophistication, statistical coverage and trained analytical strength to make them work. A judgment must also be made concerning where the marginal returns of increasing the sophistication of the system cease to justify the marginal costs involved. Many countries are markedly deficient in the resources they can mobilize for such an undertaking and large teams of A.I.D. managerial talent to perform these services is not a recommended alternative. However, this approach can be encouraged where it seems possible that necessary improvements could be made by the training of local personnel and the provision of a reasonable amount of technical assistance. The decision as to whether to initiate a crop campaign should be made on the basis of the Mission's assessment of the will of the Government and the probable ratio of benefits to costs.

4. The direct involvement of an A.I.D. Mission in a crop production campaign may require some regrouping of tasks and reallocation of Mission personnel. There must be arrangements which produce quick decisions and mobilize forces where they are most needed to break bottlenecks and contribute to the smooth operation of the system.

5. The extent to which Governments will be required to discharge functions in the crop campaign will depend on the strength and effectiveness of the private sector. In most cases, it is desirable that the private sector perform a wide range of tasks, from the distribution of fertilizer and seeds to the marketing of crops, for the more such services are provided by the private sector, the lighter will be the burden on Government administration. The role of Government in a country where the private sector is operating well can be largely confined to providing information, monitoring, and performing compensatory functions—i.e., intervening when the job is not satisfactorily performed by the private sector. An almost universal problem is the cost of these services. The services may be more efficiently performed by private enterprise but the provision of the essential infrastructure for seed and fertilizer distribution and for marketing is for the most part a responsibility of Government. The existence of a responsive private sector is of course essential to this division of labor, but in most countries Governments tend to underestimate their private sector's capacity for action A.I.D. needs to work harder on opportunities for private participation and on encouraging it And A.I.D. needs to know more about the costs of distribution and marketing, and how to reduce them.

## IV. INSTITUTIONS

*A. Findings*

No one group of Government institutions proved to be indispensable to the successful introduction of the high-yielding varieties in all countries considered. The availability of well-trained technicians, and of a flexible and popular rural institutional network capable of alignment in a campaign structure, were essential, as were a capacity for adaptive research and a procurement authority. Extension played a decisive role in a few countries: elsewhere diffusion of practices proceeded rapidly regardless of the quality of the extension service. The lack of institutionalized credit doesn't appear to have slowed the early diffusion process, especially in the wheat areas. Finally, in most places, co-ops and community development had little observable effect. Certain *functions*, such as the dissemination of knowledge, the distribution of seeds and fertilizer, etc., had

to be performed, but on balance the precise contribution to the discharge of these functions of formal and typically laboriously created *institutionalized services* is unimpressive.

It is probable that the HYVP [1] is an inadequate measure of institutional success It is also probable that the contribution of traditional institutions will become increasingly significant with elapsed time, both in expanding the HYVP and in dealing with second and third generation problems. The evidence seems to indicate, however, that, given a significant, tested, technical breakthrough to exploit, and an effective product demand, a successful production campaign can be mounted with less explicit attention to formal institutional underpinning than heretofore thought necessary.

Distinguishing among three types of institutional management helps to organize another set of lessons of the HYV experience. There are (1) the traditional government institutions, including rural and professional education, research, extension and credit; (2) private enterprise operating in the agricultural service sector—e g., ESSO, the Kenya Seed Company and other fertilizer, machinery, insecticide and seed producers and distributors; (3) farmers' co-operative institutions, which make collective decisions for farmers at the village (machine pools, fertilizer distribution) or multivillage (water supply, drainage, pest control) levels. Private enterprise offers a frequently unrealized potential for reducing the burden on governmental services. Where profits are clearly indicated, as they have been in the HYV areas, private enterprise has been quick to exploit opportunities, provided the climate for individual initiative has been favorable. Similarly, co-operative institutions have mushroomed spontaneously in certain HYV areas, once their functional utility was demonstrated. Both private enterprise and co-ops offer alternatives to government service. but of the two the former seems to be more readily responsive to deliberate government inducements and can be expected to play a leading role in diffusing future technological breakthroughs. Everywhere, however, the increased services required by the HYV's are stimulating the creation of new institutions as well as the revitalization of old ones.

*B. Implications for A.I.D.*

Some caution is advisable in applying the lessons learned in HYV campaigns to agricultural development in general. The results obtained were abnormally profitable and the urge to share in the profits an unusually powerful stimulus. Although the contribution (or lack of contribution) of individual institutions to HYV campaigns should certainly be taken into account in planning programs to support agricultural institutions it may not be a fully satisfactory indication of their worth in other situations. On the basis of experience with crop production campaigns, it is not possible to conclude that the building of any particular set of institutions will automatically result in increased agricultural production. There are indications, however, that the availability of a responsive institutional base is probably essential for the fullest exploitation of any technological breakthrough.

"1. Pending the development of further knowledge of the effect of different types of institutions over time, A.I.D. should as a first priority concentrate its institutional building efforts on those institutions with a clear multiplier effect, i.e, *research* and *professional agricultural education*. The land-grant university is an appropriate (but not the only) model, if suitably adapted to local conditions.

"2. Institution building takes time. Creating an agricultural university and bringing it to the point where with indigenous personnel it can undertake advanced agricultural education and research is inevitably a long-term project. A.I.D. needs to develop procedures which will help to assure the continuity of effort essential to the success of such undertakings.

3 A.I.D should seek to identify more precisely the character and timing of the contribution of different institutions, e.g., extension of precise technical information on the HYV package of practices was essential to rapid diffusion, but the established *extension service* was only one of several agencies which performed this role The importance of credit in the HYVP has not been clearly demonstrated. In Pakistan and India the lack of institutional credit appears to have had little significance. In Turkey and the Philippines credit is reported to have been an integral part of the program.

[1] High-yielding variety program.

4 Paragraph 3 should be read in the light of the general observation which introduces this section. The HYV campaigns were unique in the agricultural experience of the LDC's, and the extent to which they can be duplicated in other parts of the agricultural sector will probably depend on the availability of additional technological innovations of comparable simplicity and profitability. Even in the HYV campaigns, a more effective extension service and more widely available credit might have accelerated the diffusion process. If the conclusion of many at the conference is correct—that the next step in agricultural development should be crop diversification and an intensified effort to reach the small farmer—extension and credit institutions may well have a significantly greater role to play.

5. Experience with the HYVs demonstrated that *co-operative action* is readily achieved when the benefits of such action are apparent to the farmers concerned. A.I.D. should take account of this demonstrated fact in planning its programs, and should investigate the potentialities of alternative systems of providing services and of broadening farmer participation in those areas where the HYV's are creating the possibility of institutional evolution and innovation.

6. A.I.D. should endeavor to encourage a greater role for *private institutions*, particularly those of the LDCs, in performing essential services in the agricultural sector—whenever it appears that these institutions can lessen the burden on over-taxed governmental institutions, and/or provide the necessary service with greater efficiency.

7. The high-yielding varieties program served to test the availability and responsiveness of the network of national institutions. Their response to the test should be evaluated, and serve as a guide to further programs of institutional improvement. In addition to the emphasis on research and professional agricultural education mentioned in paragraph 1 above, A.I.D. should encourage increased participation of the private sector, for the reason stated in III B 5. Under certain conditions support of other institutions may be desirable:

a. Extension and credit, to help disadvantaged farmers adopt new technology, and/or to assist in promoting diversification.

b. Co-operatives, when they have a clearly defined objective and a useful role to play.

## V. MAJOR PHYSICAL INPUTS

### *A. Findings*

The so-called high-yielding varieties might be more accurately described as the highly responsive varieties. In response to increased applications of fertilizer, with accompanying protective materials such as insecticides, fungicides, herbicides, and adequate water supplies, they produce yields which greatly exceed those of native varieties.

Overall fertilizer use in the countries covered by this study is expected to grow at the compound annual rate of between 12 and 20 per cent. Increases on acreage planted to high-yielding cereal varieties will be greater.

Fertilizer costs in the LDCs are high—both for imports and for locally produced materials. Imported materials can be purchased economically in a number of developed countries, but the costs of transport and distribution greatly increases the price. Production from local plants is frequently inefficient.

Possible sources of supply available to the LDCs also include intermediates. Numerous and complex factors enter into the calculation of the most economic means for a particular country. In general the rule of thumb is: imports of finished materials when daily requirements are less than 100 tons of $P_2O_5$ and 200 tons of N; intermediates where the daily requirement is 100–300 tons of $P_2O_5$ and 200–400 tons of N; intergrated production from raw materials to finished product may be justified where daily requirements exceed these rates.

The HYV wheat varieties require planting at precise depths, and for this purpose mechanical drills are important. A good case can be made for machinery which will speed the harvest and thus facilitate multiple cropping. However, under the conditions of unemployment and underemployment which characterize most developing countries, the utilization of machinery which will displace labor should be discouraged

The HYV's have been confined predominantly to irrigated areas, plus a relatively small acreage which has an assured supply of rain. This will doubtless continue to be the case, and the spread of existing varieties of wheat and rice will probably be limited to such areas.

The lack of adequate water (and inefficient management of available supplies) is a serious constraint on general agricultural development, and severely limits the spread of the high-yielding cereal varieties. Looking ahead a decade or so, it is likely to be the most serious constraint on agricultural development. The problems are of three sorts—

1. There is grossly inadequate knowledge of the interrelations of soil, water and plants in most of the LDCs. A substantial volume of additional research is needed, much of it location specific.

2. Additional water which might be supplied is either untapped underground, or wasted as run-off. There are still vast untapped underground resources in the Indo-Gangetic plain, which could be reached by tube wells, thus expanding the area of irrigated land. Much of the rainfall in rain-fed areas (which constitute from 60–80 per cent of the arable land in the LDCs), which could be channeled into catchment areas, is simply wasted.

3. Water which is made available by irrigation works, or by rainfall, is wasted by poor management. In the flat areas of the irrigated plain, water-logging and salinity are constant problems, and they are seldom effectively dealt with. The real potential of irrigation as a means to multiple cropping is largely unrealized. Irrigation systems which flow water over entire plots from the highest to the lowest are wasteful and fail to deliver to each farm the volume of water it requires. Rain-fed areas could be made vastly more productive by small dam construction, improved contouring, water spreading, etc.

*B. Implications for A.I.D.*

1. The materials developed in the Review are consistent with the A.I.D. fertilizer policy set forth in P.D. 41, which should continue to be applied.

*2. A.I.D. should endeavor to discriminate in the types of farm machinery it finances, and concerning which it advises the Government of Host Countries. Certain machinery is essential to proper planting, or to a rapid harvest which facilitates multiple cropping, and the accomplishment of these purposes is clearly desirable. However, machinery which serves merely to supplant hand labor is probably not socially justifiable in most LDCs. Admittedly, in many cases, this principle will not provide adequate program guidance, but one practical conclusion emerges: subsidies or other special inducements for the import or manufacture of machinery likely to supplant significant numbers of laborers is unwarranted.

3 A.I.D. should encourage a substantial increase in research on the interrelations of soil, water and plants. Much work is needed to make potential water supply available, and to improve the management of available supplies. Programs which support Agricultural Universities and other local research institutions should aim to increase the capacity of these institutions to do research in these areas and to produce graduates skilled in water management—i.e., control and allocation at the source as well as on-farm use.

*4. A.I.D. Missions should encourage host Governments to adopt policies and practices which maximize the utility of available water supplies, to instruct farmers concerning desirable water management practices and to stimulate co-operative village action in applying them.

5. As the use of pesticides becomes more widespread in LDC agriculture—a development which is now accompanying the diffusion of HYV's—A.I.D. will need to concern itself with the problems they create.

## VI. RESEARCH

*A. Findings*

Continued growth in agriculture depends on a continuing flow of new technology which can only come from adequate research.

The ability of scientists to manipulate the genetic structure of plants has been applied to problems of food production in the tropics and sub-tropics only in recent years. The success of IRRI in producing IR–8 within a five-year period demonstrates the remarkable breakthroughs which may be accomplished when competent inter-disciplinary teams are mobilized to concentrate on the achievement of specifically defined objectives Although some progress has been made in widening the knowledge base and increasing the research capacity of the developing countries, the evidence is clear that for the foreseeable future the scientific structure in the LDCs will be inadequate to perform the total task required for sustained agricultural progress. Simultaneous action on two fronts is required:

a. The competence of the LDCs, themselves, to carry on agricultural research must be progressively improved, and the ultimate objective should be to bring each country to the highest level appropriate to its size, resources and agricultural problems

b. The deficiencies in scientific competence so common throughout the developing world must be compensated for, to the extent possible, by the importation of materials and skills. The mass of the world's scientific skills is now concentrated in the developed countries, in universities, research stations, foundations, the private sector, and these skills have not as yet been fully mobilized to provide both external assistance and to strengthen indigenous institutions and capabilities. (The provision of scientific skills and improved materials to the LDCs by institutions in the developed countries, incidentally, can serve other than purely altruistic purposes. The research capabilities of these institutions and their teaching competence may both benefit from involvement in the problems of the LDCs )

Some immediate improvement in many LDCs could be achieved by the more effective use of manpower already trained and available, but ineffectively utilized because of poor organization and being spread too thin through too many institutions. A long-term solution calls for an increase in the total number of scientifically trained personnel.

Among the subjects which merit priority research attention are:

a. Further adaptation of existing high-yielding rice varieties to specific locations: there is a less acute need for similar work on spring wheats, but back-up strains are needed. Winter wheats and durums suitable to the high altitude sub-tropics need to be developed.

b. Improvement of cereals for non-irrigated areas.

c. Cropping systems for the humid tropics.

d. Improved knowledge of soil fertility, plant structure, disease and insect control

e Irrigation, drainage, and other problems of water management.

f. Vegetables and legumes.

g. Technology of food processing adapted to LDC capability and market potential.

*B. Implications for A.I.D.*

*1. It is clear that there should be a significantly greater investment in research on problems of agricultural development in the LDCs, and on creating additional LDC capability to do research work. This will require a substantial increase in budgetary allocations to agricultural research in many LDCs, and a material strengthening of institutions capable of providing advanced training in the agricultural sciences. It will also require a considerable increase in A.I.D.'s own budget for the support of agricultural research and for assistance to the building of institutional competence in the LDCs.

*2. Further work is required on wheat and rice for dryland farming, and additional improvements should be sought in corn, sorghum and millets. A concerted effort should be made to develop a profitable technology for the disadvantaged farmers of these areas, comparable to the HYVs developed for areas of assured water supply.

3 The question of A.I.D.'s ability to stay for the long pull required for the ultimate achievement of long-term research goals, and to support institutions designed to contribute to these goals, has been raised in connection with the support of agricultural universities in the LDCs and needs to be raised again here. The Agency has supported certain LDC agricultural universities for more than a decade; has engaged some U.S universities in research over a span of years; and has given letters to both IRRI and CIMMYT stating the intent to contribute to these institutes on a continuing basis. Thus, the Agency is not without instruments to strengthen its commitment to long-term institutional development, and should make full use of them in the future.

*4. Greater stress in A I.D.-financed projects should be placed on building more research and service capabilities into LDC universities and other institutions:

a. Consideration should be given to the development or arrangements which will permit continued collaboration on research projects between U.S. and LDC institutions after the LDC institution "comes of age" and ceases to require continued support.

b. In strengthening local research competence, A.I.D. should, where conditions are propitious, assist LDCs in reorganizing their research capacity to greater effect. Quality of research is likely to be more important than quantity.

c. To increase the sum-total of LDC capacity, more advanced training of personnel is also required, most notably the agricultural universities (See IV. B.).

5. When A.I.D. considers phasing out the assistance program in a country which is reaching a position where general concessionary assistance is no longer justifiable, special attention should be directed to the stage of research capability achieved, and, where further assistance is required to bring agricultural research institutions to a state of maturity, means should be sought to accomplish this purpose.

6. In seeking to improve the input of skills and materials from the developed world, obviously A.I.D. needs to start from the base which already exists and to go on from there. Steps clearly indicated are the following:

*a. Support and strengthen international research centers, particularly in their capacity to assist the LDCs solve production problems and to provide training to nationals of these countries.

*b Continued support for centers of excellence on a long-term basis in the United States—both in the U.S. government institutions and in the Land-Grant universities. (A nucleus of such centers supported by A.I.D. already exists. A.I.D. depends on TVA for its basic work in fertilizers, on the USDA for economic analysis and for certain genetic work. Contracts already exist with a number of Land-Grant universities—e.g., Purdue in corn and sorghum, Nebraska in wheat, Mississippi in seeds).

c. There are other developed countries and international bodies which have capabilities in this area, and are prepared to contribute. Wherever possible, A.I.D. should encourage such participation, with the object of helping to promote a network of relationships among the various institutions around the world which are involved in related tasks.

*7. Property to encourage and support research will require improved professional competence for A.I.D. This can be done in large measure by use of USDA personnel and consultants, but it is also essential to have some strengthening of A.I.D.'s own in-house capabilities.

*8. The Agency needs a clearer overview of the research needs of the developing countries and of the network of institutions which can most effectively meet these needs. The development of a framework for wise decisions concerning the investment of additional research funds is needed. The possibility of performing this task in co-operation with the Foundations and other appropriate organizations—national and international—should be examined. The objectives of this review would be to determine—

a. what needs most urgently to be done by external research institutions (i.e., those not part of the LDC system)?

b. how should these tasks be allocated?

c. how can results achieved be more effectively tied into programs in the LDCs?

## VII—A. EMERGING PROBLEMS: CEREAL SURPLUSES

### *A. Findings*

The HYV program has demonstrated the feasibility of overcoming deficits in cereal production in Asia. Similar evidence applicable to other regions is available. But increases in rice and wheat production do not solve the problem of protein deficiency. In fact, to the extent that the cereals are planted on land formerly used to produce legumes they may even aggravate the problem

As the HYV program expands, the potential for surplus production emerges, and with it, the need for assessing its effects. Comparative advantage is a better criterion than self-sufficiency, but the latter provides a convenient benchmark.

A few favored LDCs may look forward to a cereal export position. However, the highly competitive nature of the international cereals market and the comparative advantage of some countries, mostly in the developed world, will limit this option for most LDC's. Surpluses created under the stimulus of high price supports of subsidies are unlikely to find outlets in a highly competitive export market. Supply disequilibrium among crops is likely to result from over-stimulation of a few.

With the increased yields afforded by HYVs, a smaller total acreage will be required to meet the country's cereal requirements, even assuming an increase in

effective demand for cereals. Given the anticipated limitations on the export market for cereals, it will be necessary to find alternative uses for the acreage thus freed. This development will facilitate desirable diversification to other crops and into poultry and animal production.

*B. Implications for A.I.D.*

1. Before deciding to support expanded production of a particular food crop in a particular LDC, A.I.D. should consider the following questions:

a. Is the crop now (or could it become), an important element of the local diet?

b. Is production already seriously below effective demand, or is it beginning to lag significantly behind the rate of population growth?

c. How is demand likely to be affected by rising income and population growth? (The effect of high elasticity of demand for food with rising incomes in the LDCs has not always been accurately assessed in the past. A.I.D. needs better data and more accurate analysis in this area, in order to permit effective planning.)

d. Can production be increased at lower rather than higher costs?

2. As countries move towards self-sufficiency in cereals production, A.I.D. should seek to stimulate progress in the following areas:

a. *Agricultural diversification,* to provide a basis for internal consumption patterns and, where comparative advantage can be developed, for export income. There may be possibilities for poultry and animal production in some countries which should not be overlooked.

b. *Development of the market,* to expand sales and facilitate diversification Relief of chronic food deficits will make it easier for the country to reduce the prices of cereals, to follow an expansionary employment policy through public works which are labor intensive and provide infrastructure for the agricultural sector, or to take other income distribution measures leading to increased food demand.

c. *Nutrition education,* to play an increasing role in stimulating national demand for higher quality food and the agricultural diversification needed to meet the demand.

d. *Development of agri-business,* to encourage the processing of cereal preparations and of other products of a diversified agriculture and thereby expand the consumer base, as well as provide increased employment and incomes.

3. Broadened participation by small farmers, both in production campaigns and in general increases in agricultural sector income, should be a continuing preoccupation. Initial response to the HYV is normally among the more alert and advanced farmers. Broad involvement by the less fortunate must be engineered before self-sufficiency is achieved or the resultant market squeeze will probably worsen rural poverty.

### VII–B. EMERGING PROBLEMS: SOCIO-POLITICAL EFFECTS

*A. Findings*

The introduction of HYV in the countries studied has increased wealth, and in most cases probably increased employment. But in some regions it has increased income disparities, within the region, and it has accentuated the disparity between the more productive regions with good soil and adequate water, and those not so well endowed.

These are problems which can now be readily seen; in some cases they were doubtless anticipated. Perhaps policies could have been devised which would have tended to widen the benefits and diminish the disparities which resulted from HYV introduction. Even in retrospect, however, it is not obvious what these policies could have been, given the social, economic and political environment in which the programs had to operate. Certainly a policy of seeking to maintain an equally shared poverty was not a desirable alternative.

The problem of the late adopters in favorable regions and the farmers in dryland areas—who together make up about 70 per cent of the agricultural population of the LDCs—is serious. Diffusion can and should be widened in favored areas by improved extension, improved credit, and perhaps stronger incentives. But there are obvious limits to such remedial action—those fixed by the boundaries of the favored lands, and those set by the amount of cereal the market can absorb. For the farmers of dry lands, to which irrigation cannot be brought

at an economic price, research on dry-land crops ultimately permit their production of a larger share of food grains, as irrigated lands are progressively shifted to higher quality foods. But there is no short-term solution in sight. One of the major problems is the difficulty of tapping the profits of those who have benefited most from the agricultural innovations. The budgetary resources of most LDCs are severely limited and their problems will grow more acute with the dwindling away of contributions from PL 480. Public necessity as well as simple considerations of equity require that means be found for funneling part of this newly created wealth into the state treasury. A solution of this problem might facilitate progress in leveling disparities and improving the lot of the disadvantaged.

Stresses and strains will continue, and panaceas are unlikely to be revealed by generalized social science research. These socio-political problems tend to be highly location specific, and their solution will depend primarily on the sensitivity of local political leaders. Though A.I.D.-financed research in social science may help these leaders to anticipate problems and to find solutions, it cannot supply sensitivity where none exists.

*B. Implications for A.I.D.*

1. A.I.D. should encourage LDC policies which—
   a. Channel part of the profits of farmers most advantaged by introduction of new varieties into productive enterprise and the public treasury.
   b. Use resources to construct infrastructure which will tend to benefit smaller farmers.
   c. Provide extension and perhaps credit in a manner to promote diffusion among later adopters.
   d. Provide more jobs in rural areas, e.g., by encouraging labor-intensive types of agriculture, food processing and other rural-based labor-intensive industry, and rural public works. (As indicated in VII. B. 2–b, significant additions to the food supply should facilitate the adoption of expansionary employment policies.)
   e. Do not promote the adoption of labor-saving machinery (for example by making the import or production of such machinery attractive).
2. Success in persuading host countries to avoid providing special inducements to use labor saving machinery (V. B. 2.) and support of an intensified research effort on dry-land crops (VI. B. 2.) would help to diminish socio-political strains.
3. A.I.D. should furnish assistance to those governments which desire to undertake research on the socio-political effects of introducing new agricultural technologies.

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