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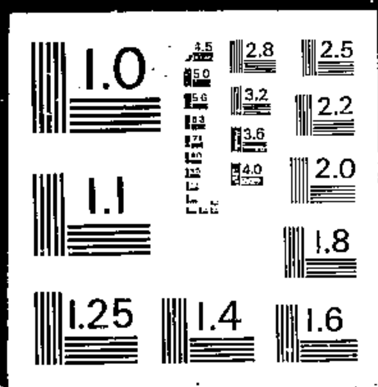

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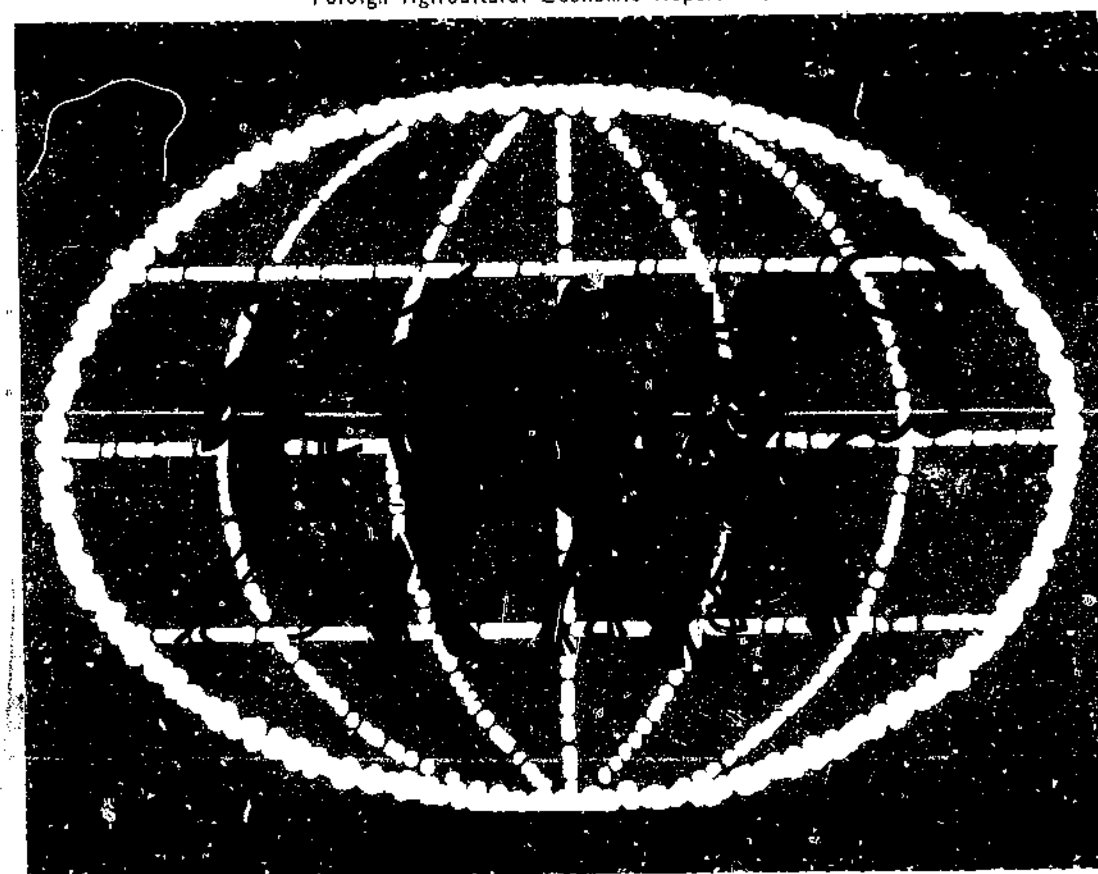
problems and prospects

Foreign Agricultural Economic Report No. 25



United States Department of Agriculture / Economic Research Service

INCREASING WORLD FOOD OUTPUT

problems and prospects

By Lester R. Brown

Foreign Agricultural Economic Report No. 25
U.S. Department of Agriculture
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PREFACE

This report supplements "Man, Land and Food: Looking Ahead at World Food Needs," Foreign Agricultural Economic Report No. 11, by the author, published in November 1963. In the earlier study, the man-land-food relationship was surveyed from the pre-World-War-II period to 1960 and projected to the end of the century. One of the principal conclusions was that possibilities of expanding the area under cultivation at reasonable cost were limited. Additions to the food supply over the remaining decades of this century would have to come largely from raising yields per acre.

The present report looks at possibilities and prospects for increasing yields, with particular emphasis on the less-developed regions. Thus far, the capacity to raise yields has been confined largely to the developed regions. Between 1934-38 and 1960, grain yields in North America increased 109 percent. But in Asia, where food needs are much greater, they increased only 7 percent. Whether the less-developed regions will be able to reverse the current downward trend in per capita food output will depend very much on their ability to develop a yield-raising capability.

Conceptually, this study owes much to W. W. Rostow and his "Stages of Economic Growth" published in 1960. Whereas Rostow applies the takeoff concept to income per person, this study applies it to yield per acre. But whereas Rostow discusses preconditions for the income takeoff, this study discusses factors facilitating the yield takeoff. The term "preconditions" used by Rostow is considered by some economists to be too rigid; thus "pretakeoff factors" or "facilitating factors" are generally used in this study. Although the terminology differs somewhat from that of Rostow, the conceptual framework remains essentially the same.

Understanding the interdependence of the income and yield takeoffs helps to explain some of the unique problems facing today's land-scarce, less-developed countries--problems not adequately dealt with by the body of conventional theory which developed in the countries of the industrial West where the two takeoffs were quite independent of each other.

Any relevant question concerning the future of the man-land-food relationship over the next few decades must focus on the productivity of land, i.e., yield per acre. It is not that this is desirable, for in terms of human welfare, output per person is more relevant. But given the lack of flexibility in the supply of cropland, in the densely populated, land-scarce countries, the level of food output per person is rather dependent on the level of food output per acre.

ACKNOWLEDGMENTS

Much of the credit for this report is due Nathan M. Koffsky, Administrator of the Economic Research Service, for his direction, especially in the formative stages. Sherman E. Johnson, Deputy Administrator, made several major contributions in the later stages of development.

The author is particularly indebted to Wilhelm Anderson, Director of the Foreign Regional Analysis Division, for valuable professional advice. Charles A. Gibbons, of the same Division, assisted with both the evaluation and interpretation of historical data.

Kenneth L. Bachman and Raymond P. Christensen of the Development and Trade Analysis Division provided useful suggestions. Lyle Schertz of the Foreign Agricultural Service offered suggestions which aided in clarifying portions of the report.

Several country specialists in the Foreign Regional Analysis Division provided data and information for the case study countries. Mary Ellen Long provided data for Australia, William F. Hall for India, Riley Kirby and Hughes H. Spurlock for Japan, and David W. Riggs for the United Kingdom.

CONTENTS

SUMMARY

In the past 25 years, some very significant changes occurred in the worldwide man-land-food relationship. Food output per person in the less-developed regions (Asia, Africa, and Latin America) dropped sharply during World War II, but trended steadily upward during the 1950's, in most cases reaching or closely approaching prewar levels. In the 1960's, however, output per person in these regions has shown a disturbing tendency to trend downward.

Before the war, the less-developed regions were exporting 11 million tons of grain per year to the developed countries. After the war, this flow reversed. During the early postwar years, 4 million tons of grain per year moved from the developed to the less-developed world. As populations growth rates accelerated in the 1950's, this flow increased, averaging 13 million tons per year in the late 1950's. In the 1960's, the flow has increased further, reaching 21 million tons in 1961 and, according to preliminary estimates, 25 million tons in 1964.

The less-developed world is clearly losing the capacity to feed itself; stated otherwise, a growing share of the increase in population is being sustained by food shipments from the developed regions, largely from the United States under the Food for Peace program.

Why is the less-developed world losing the capacity to feed itself? The answer can be stated in simple terms. Throughout history, man has increased the food supply by expanding the area under cultivation. But today many densely populated, less-developed countries have nearly exhausted the supply of new land that can readily be brought under cultivation. Nearly half of the world's people live in less-developed countries that are now essentially fixed-land economies--that is, almost all cultivable land is already in use. These countries must look to rising per acre yields for most of the additions to their food supply. They must generate a yield takeoff--a sustained rise in yield per acre.

The ability to generate a trend of rapidly rising yields, however, has been confined largely to the more advanced countries. Over the past quarter century, all the increase in food output in both North America and Western Europe came from raising yield per acre. Yield per acre in North America, the most advanced region, increased 109 percent; in Asia, the least advanced region, it increased only 7 percent, and for the entire less-developed world it rose only 8 percent.

Once yield-per-acre takeoffs are achieved, yields tend to continue upward. There is no record of a post-takeoff country in which yields have tended to level off or trend downward. If

anything, yields tend to increase at an accelerating rate after takeoff. The problem is to generate the yield takeoff. And the big question is: What is needed for a yield takeoff?

One factor facilitating a yield-per-acre takeoff is a reasonably high level of literacy. A trend of rapidly rising yields implies the continuous movement of new ideas and techniques from the research plot to the farmer, and this is much easier in a largely literate society.

Rates of yield increase vary widely among countries with widely varying literacy levels. Major grain producing countries with literacy levels below 50 percent raised yields at 0.2 percent per year between 1935-39 and 1960-62. Those with literacy levels between 50 and 80 percent achieved a 1.1 percent annual rate of gain; those above 80 percent averaged 1.4 percent.

There is also a close relationship between the average level of income per person in a country and its ability to raise output per acre. Countries with average per capita incomes below $200 per year raised yields an average of 0.2 percent per year between prewar and 1960-62. Those with incomes between $200 and $1,000 averaged a 1.0 percent rate of yield increase. And those with incomes above $1,000 averaged more than 2.2 percent per year.

Another factor facilitating a yield-per-acre takeoff is the development of a market oriented agriculture. In subsistence-type economies, the share of farm output entering the market is often very small, limiting the amount of cash which farmers have to purchase yield-raising inputs such as fertilizer. This was not a serious handicap when food output could be increased by simply expanding the area under cultivation.

Agriculture is often quite independent of the remainder of the economy in an area-expanding situation, but as it becomes possible to increase the food supply only by raising yields, agriculture becomes quite dependent on the remainder of the economy for a wide variety of goods and services, varying from capital inputs such as fertilizer and pesticides to services such as research, credit, and transportation. Thus, the ability to raise yields is closely related to the level of development of the nonagricultural supporting sector.

The failure of a fixed-land economy with a rapidy growing population to achieve a yield takeoff is serious. Food output per person begins to trend downward, and because the agricultural population continues to grow, throughout the early stages of development, output per person in agriculture also begins to decline. With the greater part of the population still in agriculture, this makes a per capita income takeoff for the total population exceedingly difficult.

Although the factors described above may facilitate a yield takeoff they are not in themselves sufficient to cause a yield takeoff. In addition, certain incentives are required.

Favorable prices for farm products are an important incentive. The term "favorable prices" in this study means favorable compared with the cost of the purchased inputs required to raise yields. Less-developed economies usually have much lower food prices and much higher fertilizer costs than developed economies. For example, a pound of rice in Japan buys three times as much ammonium sulphate as a pound of rice in India. This relationship between prices of farm products and costs of yield-raising inputs was not so important when new land was still available.

But favorable prices for farm products is not enough. The people on the land must be the principal beneficiaries of these favorable prices. There must also be a strong link between effort and reward. The strength of this link is affected by such factors as patterns of land tenure and tax systems. The less-developed countries which have become fixed-land economies before achieving a per capita income takeoff are faced with the necessity of achieving the income per person takeoff and the yield per acre takeoff at the same time.

To describe what it takes to generate a yield-per-acre takeoff is, in a sense, to describe the process of modernization and development. Stated otherwise, the more advanced an economy is the easier it is to generate a yield takeoff. The densely populated, less-developed countries, which have virtually exhausted the supply of new land that can readily be brought under cultivation must compress a lot of progress into a very short period of time if they are to generate the yield takeoff needed to feed their rapidly growing populations.

INCREASING WORLD FOOD OUTPUT: Problems and Prospects

By Lester R. Brown,
International Agricultural Economist[1]

Chapter I.--DEFINING THE PROBLEM

The problem can be simply stated: the less-developed world is losing the capacity to feed itself. The purpose of this study is to determine why this is happening and what can be done about it.

During the years preceding World War II, the less-developed regions of Asia, Africa, and Latin America were all net exporters of grain. Together they exported, on a net basis, 11 million tons of corn, wheat, rice, and other grains per year to the developed world. By the close of World War II, these regions had lost their export surplus of grain; indeed, the direction of flow of grain was reversed.

From 1948 to 1952, an average of 4 million tons of grain per year moved from the developed to the less-developed regions. As the rate of population increase in the less-developed regions gained momentum during the 1950's, the flow increased, reaching 13 million metric tons annually during the 1957-59 period. In fiscal 1961, the net transfer of grain from the developed to less-developed regions reached a high of 20 million tons. Thus far in the 1960's, the disparity between food needs and food output in the less-developed regions has continued to grow, with preliminary estimates for fiscal 1964 showing net imports of 25 million metric tons.

Stated otherwise, the less-developed parts of the world, now containing 2.2 billion of the world's 3.1 billion people, can no longer provide enough food for the large numbers being born each year. A growing part of the increase in population is being sustained by food shipped from the developed world, principally North America.

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[1] This study was undertaken while the author was on detail from the Foreign Regional Analysis Division of the Economic Research Service to the office of the Administrator, ERS, where he acted as Assistant to the Administrator. Since completion of the study, the author has become a member of the Department's Staff Economist Group.

The food situation in the less-developed world appears the same whether viewed in terms of trends in trade or trends in per capita food output. During the 1950's, per capita food output in the less-developed regions trended upward, generally regaining prewar levels. But thus far in the 1960's, their average per capita output has been declining.

Food output per person in Asia, excluding Mainland China, has dropped 4 percent from the postwar high in 1961; Mainland China reached a postwar high in 1958 and, according to available evidence, has dropped even more; Latin American output has declined each year since 1958, dropping 6 percent in 5 years. Only in Africa, where per capita food output has remained essentially unchanged in recent years, has a downward trend been avoided.

Identifying Some Common Sources of Confusion

The scope and complexity of the food problem and the implications of present trends are not well understood. Factors rendering a proper assessment difficult range from the uncertain influence of weather to the lack of reliable data. Some common sources of confusion are outlined here.

Postwar Recovery Projections

Beginning in the late 1950's government policy makers, economic development planners, and businessmen found it increasingly necessary to make decisions based upon estimates of food supply-demand relationships for some date in the distant future. Many long-term projections of food supply and demand were undertaken in response to this need.

Reasonably accurate projections of population growth were available by the late 1950's and assumptions could be made concerning expected rates of increase in per capita income, the other principal factor influencing demand for food. Thus, demand projections were reasonably simple and straightforward. But on the supply side, much less was available in the way of projections, and much less was known about supply projection techniques. Lacking anything better, many projections of output were made simply by extrapolating the food output trends existing from the late 1940's to the late 1950's or alternatively from the early 1950's to the late 1950's or early 1960's. Overlooked was the fact that increases during this period often consisted in large part of recovery from the destruction and disruption of World War II.

Near the end of the 1950's per capita output levels in the less-developed regions began to approach the levels existing before the war. But the gains made during the 1950's were in a sense illusory. Once recovery was complete, the rate of gain began to slow down--making the supply projections unduly optimistic. And in some cases this unwarranted optimism contributed to a shift of emphasis from agriculture to industry. Only now are the effects of this shift becoming evident as many less-developed countries are plagued with growing shortages of food.

Weather Always Responsible

Reduced crops and subsequent food shortages are frequently attributed to bad weather, but in reality weather is not wholly to blame. It is often a scapegoat, covering a multitude of shortcomings, bureaucratic and otherwise. A year of unfavorable weather often serves to bring into focus a steadily worsening situation.

Weather was held responsible for the development of a grain deficit in India in the 1950's. But several years have passed and the deficit persists, larger than ever before. Mainland China switched abruptly from being a net exporter of grain in 1960 to being a sizable net importer in 1961. Adverse weather of an "unprecedented" nature was deemed responsible. Today, 4 years later, Mainland China continues as a leading grain importer, purchasing 5 to 6 million tons annually in the international market.

Late in the summer of 1963, official news releases of the Soviet government began mentioning the disastrous weather in the virgin lands wheat-growing regions. Shortly thereafter, it was learned that the Soviet Union was negotiating to buy large quantities of wheat from Canada. Within the course of 1 year, the Soviet Union made the transition, at least temporarily, from a sizable wheat exporter to the world's leading wheat importer. Weather was reported responsible. But subsequent actions indicated that the Soviet Government, in fact, thought factors other than weather were involved. The possibility of having over-extended the cultivated area was mentioned in official Soviet statements. Mention was made in journal articles of the continuous reduction of the land in fallow, accompanying the determined efforts to increase food output (84)[2]. In late 1963, plans were announced for remedying the situation by greatly expanding the use of fertilizer. These are but a few examples where weather may have been held responsible to an extent not entirely warranted.

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[2] Underscored numbers in parentheses refer to items in the Bibliography, p. 116.

Declining Birth Rates Imminent

Many observers, though recognizing the existence of a food crisis in the less-developed regions, believe that birth rates will shortly be reduced, thus alleviating the pressure on food supplies. This belief stems from 3-stage demographic transition model set forth several years ago (68). The stages in this model represent 3 stages of development as characterized by changes in the relationship between birth rates and death rates.

In Stage I, the society is essentially traditionalist, with high birth and high death rates. High death rates, reflecting particularly a low rate of survival among infants, offset the high birth rates, resulting in very low, often negligible, rates of population growth. This stage prevailed throughout much of human history.

Stage II is characterized by the introduction of modern medical science, including mass inoculation, malaria eradication campaigns, and public health facilities. There is an abrupt decline in death rates, but birth rates continue high. The historical equilibrium between births and deaths is destroyed, and population begins to grow rapidly. Nearly all the less-developed countries, with their unprecedented rates of population growth, are now in Stage II.

As countries reach advanced levels of development, birth rates drop, and they are in State III. Low birth rates and low death rates combine to produce a new equilibrium, characterized by low rates of population growth. Most European countries, with population growth rates below 1 percent per year, have been in Stage III for several decades.

Often overlooked is the fact that the reduction in birth rates is usually closely associated with reaching a rather advanced level of living. It is now becoming evident that many densely populated, land-scarce, less-developed countries are experiencing great difficulty in significantly improving living levels. But without this improvement, birth rates are not expected to decline and an already tenuous situation could become worse.

In support of the model outlined above, the dramatic decline in Ireland's population growth rate occurring during the 19th century was not due to stage II improvements. Population grew rapidly in Ireland during the century preceding the famine of the 1840's. During the famine, population began to decline. The most immediate cause of the reduction in population was starvation: An estimated 1 to 1.5 million of a total population of 8 million died of starvation during the famine. Many more emigrated. Emigration, late marriages, and permanent spinsterhood for a large percentage of the women combined to reduce population further, until it reached the

2.8 million of today. In recent decades, Ireland's population has continued its long-term decline at about 0.4 percent per year (48, 58).

Japan is the only Asian country to materially reduce its population growth rate. Between the late 1940's and middle 1950's, Japan's population growth rate dropped from nearly 2 percent per year to less than 1 percent. But this followed nearly a century of industrial development and economic progress. Japan was no longer a Stage II country.

Several decades were required for the demographic transition in Western countries, and the population multiplied several fold during the process. The less-developed countries, many already densely populated, do not have the resources to cope with increases of this magnitude.

The Critical Transition

Throughout much of history, increasing food output has been largely achieved by expanding the area under cultivation. In many countries in the Middle East and South Asia, cultural practices, and therefore probably also yields, have changed little over the centuries.

Today opportunities for finding new land that can readily be cultivated are limited. Future additions to the food supply in the less-developed regions must come largely from raising yields. India, during the 15-year span encompassing the 3rd, 4th, and 5th 5-year plans, expects to expand by reclamation the net area used for agriculture by only 6 million acres, or less than 0.2 percent per year. But population is growing at 10 times this rate--well above 2 percent per year. Clearly, if food output is to increase as fast as population does, most of the increase will have to come from raising output per acre. Annual output per acre of land may increase either as a result of increases in yield per crop acre harvested or an increase in the number of crops per acre per year.

Although reliable data for development plans in Mainland China are not available, it seems likely that China is similarly dependent on raising yields for additional food output. To these 2 large less-developed countries must be added others such as Pakistan, South Korea, Ceylon, Guatemala, Egypt, Haiti, Iran, Iraq, and Turkey. Thus, two-thirds of the 2.2 billion people living in the less-developed regions of Asia, Africa, and Latin America are in countries that are heavily dependent on higher yields for additional food.

Expanding the area under cultivation to increase food output is not new. Man has been using this method ever since the first crops were planted. But near-total dependence on raising yields for additions to the food supply is relatively new, especially in the less-developed regions. As will be seen later, far more is involved than simply moving to new land.

Situations Not Parallel

There are certain basic differences between the conditions under which the advanced economies of the Western world initiated their development and the conditions under which the less-developed countries of Asia, Africa, and Latin America are today endeavoring to industrialize. Most of these differences do not favor those countries now attempting to develop. These are:

(1) The area of agricultural land per person is only a fraction of what it was in the now-advanced countries at a comparable stage in their development.

(2) In several major less-developed countries, the expansion of the food-producing area has almost reached its limits before takeoff.

(3) Population growth rates confronting today's less-developed countries are far higher than those experienced by the developed countries during a comparable stage of development, or, for that matter, at any time in their history.

(4) The land-man ratio is declining much more rapidly in today's less-developed countries because of (a) higher rates of population growth, and (b) limited possibilities for expanding the area under cultivation.

(5) Significant opportunities for emigration as a means of alleviating population pressure do not exist for today's less-developed countries.

(6) The first countries to industrialize had a technical lead over the rest of the world, enabling them to profitably exchange manufactures for the food and raw materials they needed. This gave these countries much more flexibility in adjusting food supplies to requirements through imports. But, unfortunately, the countries now attempting to develop do not have this advantage.

Some of the differences between the two groups of countries favor the currently less-developed countries. These are:

(1) A considerable backlog of technology exists in the developed world from which countries that only now are developing can freely borrow.

(2) The less-developed countries, having examples to follow, know that development is possible.

Abruptness of Transition

In less-developed countries where capital is scarce, agricultural technology is traditional, and the population is growing rapidly, there is a strong tendency to increase output by expanding the area under cultivation until the supply of potentially cultivable land is almost exhausted. The need to make the transition then develops very suddenly. These countries must make the transition in a time span measured in years rather than in decades or centuries as was the case with the more advanced economies.

The advanced economies of Western Europe, the first to industrialize, were able to trade their manufactured goods for foodstuffs, and postpone the need for a yield takeoff. The United Kingdom, though faced with a long-term gradual increase in food needs, dating back to at least the beginning of the industrial revolution, was able to postpone its yield takeoff until World War II when food supply lines were severed. The advanced economies of Canada, the United States, and Australia had vast virgin land areas to bring into food production. These countries were quite advanced by the time their frontiers had disappeared and they had to shift to yield-raising to increase food output.

Given the rapid population growth rates characterizing the less-developed countries, the inability to make the transition from the area-expanding method to the yield-raising method will result either in growing dependence on external sources for food or in declining per capita food supplies.

The Central Question

The problem facing the less-developed countries can be simply stated. In the future, they must look to rising output per acre for most of the required increases in their food supply.

The central question then is this: How quickly can the less-developed countries make the transition from the area-expanding method of increasing food output to the yield-raising method of increasing food output?

Chapter II.--APPROACHING THE PROBLEM

The Takeoff Concept--A New Application

The concept of an income takeoff--an abrupt change from a condition of near static per capita income to one of steadily rising per capita income--is now an integral part of development theory. (77) The takeoff concept can also be quite appropriately applied to yield per acre. It is, in fact, easier to apply the takeoff concept to yields than to incomes because changes in yields, being measured quantitatively, are more easily discerned. Measurements of change in real incomes are often made difficult by changes in the real value of the currencies used.

The behavior of per capita incomes and per acre yields over periods of time is remarkably similar. Throughout most of history, both have been either static or increasing at scarcely perceptible rates. Although civilization has existed for several thousand years, the first per capita income takeoff did not occur until about 2 centuries ago in the United Kingdom.

It is difficult to say which country was the first to achieve a yield per acre takeoff, but there was a considerable time lapse between the first income takeoff and the first yield takeoff. Japan, which experienced a yield takeoff during the last quarter of the 19th century, may have been the first. The only countries which might have experienced a yield takeoff as early as Japan would have been some of the smaller countries of northwestern Europe, such as Denmark or the Netherlands, and judging by current yield levels, their takeoffs could not have greatly preceded that of Japan.

A yield per acre takeoff is defined as a rapid, continuous increase in yields sustained over an extended period, say 15 to 20 years.[1] An increase maintained for a shorter period of time

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[1] Records on grain yields for most countries are based on grain yield per harvested acre. Thus, it is possible for annual output per acre of cropland to either increase or decrease, while yield per harvested acre remains unchanged. If the proportion of land in fallow increases, the yield per harvested acre may

Footnote continued on next page.

might not be a takeoff at all but simply a move to a slightly higher plateau.

Movements to higher plateaus are often associated with one-time increases such as the effect of an irrigation project. If the area brought under irrigation includes a significant share of the total acreage of a single crop, the full effect of the project on yields may be concentrated in a short period of a few years. Yields will rise rapidly for a few years but then level off, tending to become static again. There is no continuing yield increase and so no take-off.

Care should be taken not to confuse the sizable, sustained increases in yields occurring during recovery periods after a war with a genuine takeoff. High rates of increase in yields common during the decade or so following World War II often declined markedly once prewar yields were regained. Countries with little or no new land to bring under cultivation must achieve rates of yield increase closely approximating rates of population growth if per capita output levels are to be maintained.

Identifying the Pretakeoff Factors

Countries vary a great deal with respect to their capacity to raise per acre yields. Some have tripled yields over the last several decades. In other countries, yields have not increased at all.

Those economies with a demonstrated capacity to raise yields in a rapid and continuous fashion are identifiably different from those with static yields. The identification of those relevant differences, whether they be in level of literacy, prices of farm products, or one of many other possible factors, is necessary to formulating policies designed to help land-scarce, less-developed countries increase their food output.

Rostow (77, p. 39), by isolating the seemingly relevant pretakeoff factors common to all countries which had experienced an income takeoff, was able to describe the "preconditions" for an

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Footnote continued.

increase while the yield per acre of cropland decreases. If, on the other hand, the extent of multiple cropping increases, output per harvested acre may decline while output per acre of cropland rises. To illustrate, the practice of multiple cropping in India, though not very widespread, has become more common in recent years, due largely to the increased availability of water during the dry season. Thus, output per acre of cropland has been rising slightly more than output per acre harvested.

income takeoff. Three basic and interrelated factors are set forth. These deal with the rate of saving, development of one or more leading manufacturing sectors with a fast rate of growth, and a situation which "exploits the impulse to expansion . . . giving to growth an onward going character."

The following chapters are devoted to a systematic examination of the factors facilitating a yield-per-acre takeoff.[2] Five major countries--Australia, India, Japan, the United Kingdom, and the United States--on which grain yield data are available for at least all of this century, and in some cases a good part of the 19th century as well, are selected for study.

The use of grains, rather than all crops combined, greatly simplifies the yield analysis without appreciably detracting from the results. Grains are sufficiently similar that they can be aggregated on a weight basis; if all crops were included, this would not be possible. And grain data are more consistent and complete than are data on other commodities. Trends in yields of grains are conceptually quite simple and easy to compute.

The use of grains as an indicator of trends in crop yields or food production is not unreasonable because grains account for 71 percent of the world's harvested crop area. In food terms, they provide 53 percent of man's supply of food energy when consumed directly and a sizable part of the remainder when consumed indirectly in the form of meat, milk, and eggs.

The long-term grain yield trends in these 5 "case-study" countries are examined to see if, and when, yield takeoffs occurred. Some factors common to those countries experiencing takeoff are then identified. In addition, changes in yields of rice, wheat, and corn between 1934-38 and 1960-62 in each of the major producing countries are examined with regard to level of literacy and level of income.

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[2] See preface for discussion of the relationship between the term "preconditions" used by Rostow and the terminology used in this study.

Chapter III.--HISTORICAL GRAIN YIELD TRENDS IN SELECTED COUNTRIES

Several criteria were involved in the selection of the case-study countries: Australia, India, Japan, the United Kingdom, and the United States. The overriding criterion was simply the availability of long-term historical data on production, area, and yield of grain (table 1 and appendix tables). Selection among those countries with available data was designed to give a good cross section according to geographic location, climate, stage of development, demographic characteristics, and the major grain produced.

One of the principal factors limiting the number of countries eligible for long-term historical study was the lack of geographical continuity. This was particularly true in Europe, where the World Wars caused extensive boundary changes in many countries. Three of the countries selected--Australia, Japan, and the United Kingdom--are insular, a factor contributing much to stability of geographic boundaries. India underwent boundary changes as a result of the partition of British India into what is now India and Pakistan. Partition is not a serious problem in this respect, because yield trends of these countries remained remarkably similar after partition.

Climatically, the countries selected range from moist, high year-round rainfall in the United Kingdom and Japan to the very arid climate of all but the coastal margins of Australia. India has a monsoonal climate characterized by a rainy season followed by a dry season of several months' duration. The United States encompasses a wide variety of climatic regions.

The case-study countries vary widely as to level of development. The United States is the world leader in terms of economic and technological development. Australia and the United Kingdom are quite advanced; Japan is at a more intermediate stage of development; and India is currently one of the less-advanced countries.

The case-study countries vary widely according to demographic characteristics. Japan, India, and the United Kingdom are among the world's most densely populated countries; the United States, and even more so, Australia, are among the least densely populated. Annual rates of population growth in recent years range from less than 1 percent per year in Japan and the United Kingdom

Table 1.--Grain yield per acre: Historical trends in Australia, India, Japan, the United Kingdom, and the United States (Kilograms)

Year	Australia[1]	India[2]	Japan[3]	United Kingdom[4]	United States[5]	Year	Australia[1]	India[2]	Japan[3]	United Kingdom[4]	United States[5]
1866	--	--	--	--	499	1915	396	288	878	758	598
1867	--	--	--	--	511	1916	363	--	901	729	490
1868	--	--	--	--	529	1917	332	--	872	743	550
1869	--	--	--	--	479	1918	272	--	858	797	516
1870	--	--	--	--	565	1919	218	--	937	702	496
1871	--	--	--	--	542	1920	438	283	944	727	567
1872	--	--	--	--	570	1921	368	--	848	766	500
1873	--	--	--	--	480	1922	314	--	927	721	511
1874	--	--	--	--	462	1923	361	--	850	745	469
1875	--	--	--	--	537	1924	416	--	886	780	506
1876	--	--	--	--	517	1925	309	272	955	782	534
1877	--	--	--	--	547	1926	374	--	899	790	506
1878	--	--	478	--	536	1927	272	--	970	800	521
1879	--	--	558	--	555	1928	300	--	952	828	544
1880	--	--	579	--	539	1929	237	--	883	860	494
1881	--	--	537	--	421	1930	325	263	972	765	463
1882	--	--	563	--	554	1931	352	--	903	767	509
1883	--	--	553	--	504	1932	369	--	965	815	522
1884	--	--	518	753	575	1933	323	--	1,101	847	435
1885	223	--	593	765	560	1934	291	--	893	961	380
1886	275	--	673	713	514	1935	325	263	960	846	486
1887	319	--	704	728	471	1936	326	--	1,047	795	398
1888	201	--	667	725	570	1937	364	--	1,048	777	544
1889	307	--	585	748	593	1938	237	--	1,012	875	521
1890	283	--	647	791	451	1939	416	286	1,123	859	550
1891	271	--	665	770	609	1940	182	283	1,016	875	567
1892	305	--	682	731	509	1941	381	277	902	847	594
1893	303	--	635	663	482	1942	434	269	1,012	940	659
1894	257	--	732	784	445	1943	366	273	943	928	599
1895	190	--	694	696	577	1944	165	284	956	900	614
1896	189	--	625	758	583	1945	311	263	734	928	622
1897	224	--	596	737	514	1946	244	242	950	886	656
1898	248	--	783	822	554	1947	432	244	967	782	571
1899	233	--	675	778	565	1948	396	261	1,051	970	720
1900	276	281	712	719	558	1949	462	242	1,019	1,023	631
1901	242	--	773	722	431	1950	416	244	1,025	967	666
1902	101	--	633	804	600	1951	397	224	1,022	1,012	652
1903	396	--	687	740	544	1952	484	230	1,111	1,047	691
1904	263	--	811	713	573	1953	474	252	965	1,117	679
1905	[illegible]	296	644	767	628	1954	396	281	1,064	1,067	688
1906	338	--	754	797	639	1955	476	275	1,263	1,227	739
1907	253	--	806	822	545	1956	438	265	1,130	1,151	734
1908	[illegible]	--	833	767	542	1957	288	275	1,176	1,117	830
1909	332	--	839	817	550	1958	533	259	1,210	1,135	940
1910	379	282	749	760	612	1959	405	296	1,278	1,301	910
1911	287	--	830	758	486	1960	524	288	1,326	1,267	987
1912	355	--	816	703	606	1961	454	305	1,320	1,288	1,014
1913	319	--	825	753	488	1962	493	302	1,364	1,460	1,078
1914	92	--	851	780	541	1963	525	307	1,214	1,388	1,123

[1] Total grains include wheat, barley, corn, and oats; yields are calculated on basis of area sown.

[2] Data to 1935 are 5-year averages, including rice and wheat only, and covering all of British India. Data after 1935 exclude Pakistan and include, in addition to wheat and rice, corn, jowar, bajra, barley, and ragi, but excluding small millets.

[3] Rice, wheat, and barley included.

[4] Data include wheat, barley and oats.

[5] Wheat, corn, and oats only in early years; rice and barley added in 1909; grain sorghums added in 1929.

to 2.2 percent per year in India. India alone among the case-study countries has both a dense population and a continuous rapid rate of population growth.

Each of the 3 leading grains--rice, wheat, and corn--is well represented in the case-study countries. Rice dominates Japanese agriculture, accounting for some three-fourths of total grain production. Wheat is the principal grain grown in Australia, where it accounts for four-fifths of total grain output. Corn is the chief grain in the United States, exceeding all other grains combined in quantity produced. Rice is the principal grain produced by Indian farmers, accounting for nearly half of total grain output. In the United Kingdom, barley is the leading grain, followed by wheat and oats.

Each of the countries included either is representative of a large group of other countries or is a special situation of value in itself. The United Kingdom is representative of several West European countries with regard to types of grain produced, temperature, rainfall, and level of economic development. It is especially representative of Denmark, Belgium, West Germany, France, Sweden, and the Netherlands.

Japan has an advanced rice culture with a land-man ratio that is quite low, which is instructive when considering other densely populated but less-advanced rice cultures such as India, China, Pakistan, Indonesia, and Ceylon.

India was selected because in spite of its boundary changes it has the most reliable data among the 4 most populous less-developed countries. India's problems are in many ways similar to those of China, Pakistan, and Indonesia. Together these 4 countries contain 1.4 billion people, nearly half the world total.

Both the United States and Australia have placed primary emphasis on output per person rather than output per acre. The United States also illustrates what can be achieved when the most advanced technology is applied to agriculture. Australia, with nearly all its grain produced in the semiarid regions, provides some useful examples of increasing grain yields in the broad semiarid grain-producing belt stretching across North Africa, the Middle East, and central Asia to the Pacific Ocean.

Japan: An Early Takeoff

An analysis of the long-term trend in grain yields in Japan is of particular interest because it was one of the first, or possibly the first, country to experience a grain yield takeoff. Japan's takeoff, first in evidence about 1880 (fig. 1), and becoming a certainty by the turn of the century, preceded the takeoffs of the United Kingdom and the United States by half a century.[1]

Contrary to widespread opinion, year-to-year increases have never been rapid or dramatic. But they have been remarkably steady and consistent. From 1878-80 to 1901-05, grain yields gained an average of 1.2 percent per year (table 2); during the

[1] Although annual yield data for all of Japan were not available until 1878, available evidence indicates that average annual rates of increase prior to this time were very low, often scarcely perceptible.

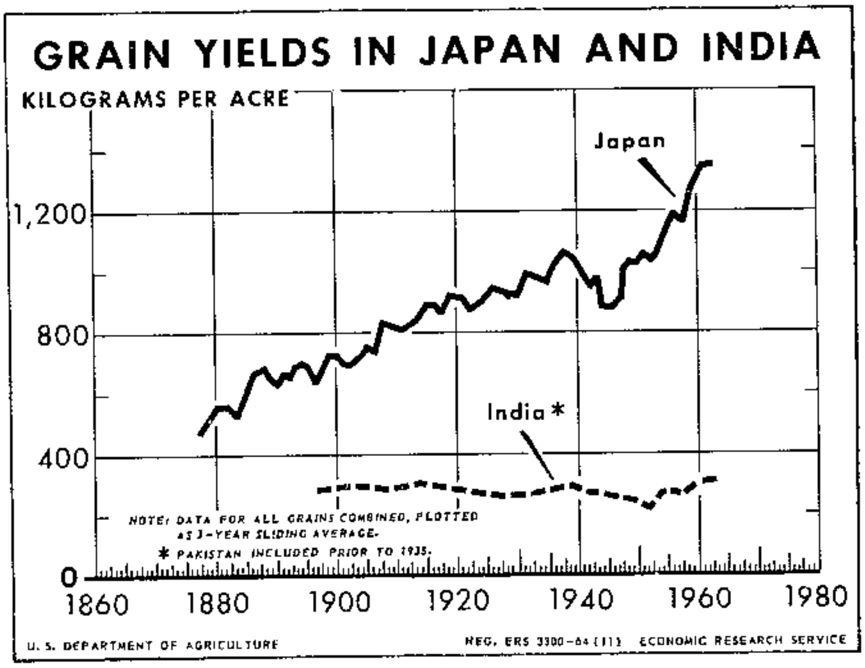

Figure 1

first 4 decades of this century, from 1901-05 to 1936-40, yields increased 1.1 percent per year; and, although yields dropped sharply as a result of the collapse of the Japanese economy following World War II, recovery was rapid with the result that the rate of increase in yields between 1936-40 and 1960-62 averaged a very creditable 1.1 percent per year.[2]

W. W. Rostow comments that income takeoffs are often associated with some particularly sharp stimulus (77, p. 38). Included are political revolutions, key technological innovations, and changes in the international environment. The same appears to be true for yield takeoffs. In the case of Japan, the stimulus appears to have been the Meiji restoration of 1868. Before 1868, Japan consisted of some 200 rather loosely federated feudal baronies scattered throughout the islands comprising present-day Japan. But after the Meiji restoration, Japan had a strong unified government for the first time. The national government, recognizing that some areas were advanced agriculturally while others were quite backward, was active in supporting the spread of the more advanced

[2] Average annual rates of increase used here and throughout this study are compound rates.

Table 2.--Change in grain yield per acre in selected countries for selected historical periods, 1866-1963

Country	Earliest period to 1901-05[1]	1901-05 to 1936-40	1936-40 to 1951-53	1951-53 to 1961-63[2] [3]
	Total change (percent)			
Australia...........	-4.0	+18.4	[4] +43.5	+8.6
India[5]	N.A.	-3.7	-12.3	[6] +22.5
Japan...............	+32.0	+47.7	-1.5	+29.9
United Kingdom......	+1.9	+11.3	+26.7	+30.2
United States.......	+7.6	[7] -1.6	+23.4	+59.1
	Annual compound rate of change (percent)			
Australia...........	-0.3	+0.5	+2.6	+0.8
India...............	N.A.	-0.1	-0.9	+2.1
Japan...............	+1.2	+1.1	-0.1	+2.6
United Kingdom......	+0.1	+0.3	+1.7	+2.7
United States.......	+0.3	0	+1.5	+4.8

[1] The years covered in this period are: Australia, 1886-90 to 1901-05; Japan, 1878-80 to 1901-05; United Kingdom, 1884-85 to 1901-05; United States, 1866-70 to 1901-05.
[2] For India, 1948-50 was substituted for 1951-53 since yields in both 1951 and 1952 were, in all probability, the lowest of this century.
[3] For Japan, 1963 was omitted because yields of winter grains in 1963 were less than half of normal.
[4] Most of the increase recorded for this period occurred after 1946.
[5] Data pertain to British India in 1901-05 but thereafter they pertain to the area covered by post-partition India.
[6] It should be noted that the increase in yields was largely recovery, i.e., regaining the levels prevailing before the disruption associated with World War II and partition in 1947.
[7] For the United States, 1936, an abnormal year, was omitted from the average.

Source: Derived from Table 1.

practices. In the words of an FAO study, "From the beginning of the Meiji period there had been a spontaneous spread of improved practices that had been developed by outstanding farmers through a process of trial and error" (41). Isolated advances had occurred from time to time before the Meiji restoration, but they were not broadly disseminated until after unification. This spread of improved practices developed by individual farmers or particular villages was undoubtedly a major factor contributing to the rather abrupt yield takeoff in evidence by 1880.

In addition to the spread of improved agricultural practices developed indigenously, the latter part of the 19th century was also characterized by a search for improved farming techniques abroad. Japanese officials visited England, Germany, the United States, and other advanced agricultural nations, learning of new scientific practices that could be applied to Japanese agriculture. Many mistakes were made in attempting to transfer techniques developed for large-scale farms of the West to Japan's very small farms. But Japanese agriculturists learned much about the scientific approach to agriculture. They gained particularly from information obtained on chemical fertilizers and how they might increase yields.

Perhaps the single most important fact influencing the historical trend in grain yields was the early realization that higher yields were essential to Japan's overall development. Possibilities for expanding the area cultivated were already quite limited in 1868. The area under cultivation today is little more than it was in the latter part of the last century, when the yield takeoff began.

Because grain production in Japan consists largely of rice, the discussion of factors contributing to the long-term gradual rise in grain yields will focus on rice. Although many factors have contributed, 3 are dominant. These are (1) water control--the construction and improvement of facilities for irrigation, drainage, and storage of water; (2) the use of chemical fertilizers; and (3) the development of improved varieties, especially varieties that respond to chemical fertilizers.

Another contribution to raising rice yields was the development of the method of rice cultivation now commonly referred to in rice-producing countries as the "Japanese paddy method." This method differs from both the traditional broadcast and the transplanting method used in most other Asian rice-producing countries. With both the traditional transplanting method and the Japanese paddy method, rice seedlings are started in a protected seedbed and transplanted into the field by hand. But with the Japanese paddy method, plants are carefully set in rows, so hand cultivators can be used. Planting in rows helps farmers obtain more uniform stands, better ventilation, and optimum plant density. The Japanese paddy method also requires heavy applications of fertilizer and a dependable source of water.

Throughout most of the period from the restoration in 1868 to the present, rice prices trended generally upward. In recent years, the upward trend has been sustained by government support of prices. As a result of this long-term trend, Japanese producer prices for rice are today far higher than in any other major rice-producing country.

In summary, Japan's yield takeoff was a difficult one. It was achieved with a minimum of mechanization, a low level of per capita income, and at a very early stage of development. If the yield takeoff had been much more difficult, it might well have failed. And, with its failure, the chances of a per capita income takeoff would have diminished greatly.

United Kingdom: Takeoff Postponed

Grain production in the United Kingdom consists largely of wheat, oats, and barley. Available evidence indicates that per acre yields of these grains have been moving upward only very gradually over the past several centuries. From the time national yield data first became available in 1884 until the advent of World War II, the average rate of increase was only 0.2 percent per year. But from 1936-40 to 1951-53, the rate of increase was 1.7 percent. And during the 1950's, it climbed still further to 2.7 percent.

A first glance at the historical trend in grain yields in the United Kingdom is likely to be misleading as to the actual date of takeoff (fig. 2). The level of grain yields, static from 1884 to the late 1920's, when they began to rise slowly, would suggest the beginning of a takeoff around 1925. But actually the modest yield increases in the late 1920's and 1930's were not necessarily the result of changes in technology as would be needed to generate and sustain a rising yield trend, i.e., a yield takeoff. These early modest increases from 1925 to 1940 seem due more to the large-scale reduction in area planted to grain during this period than to any other single factor.

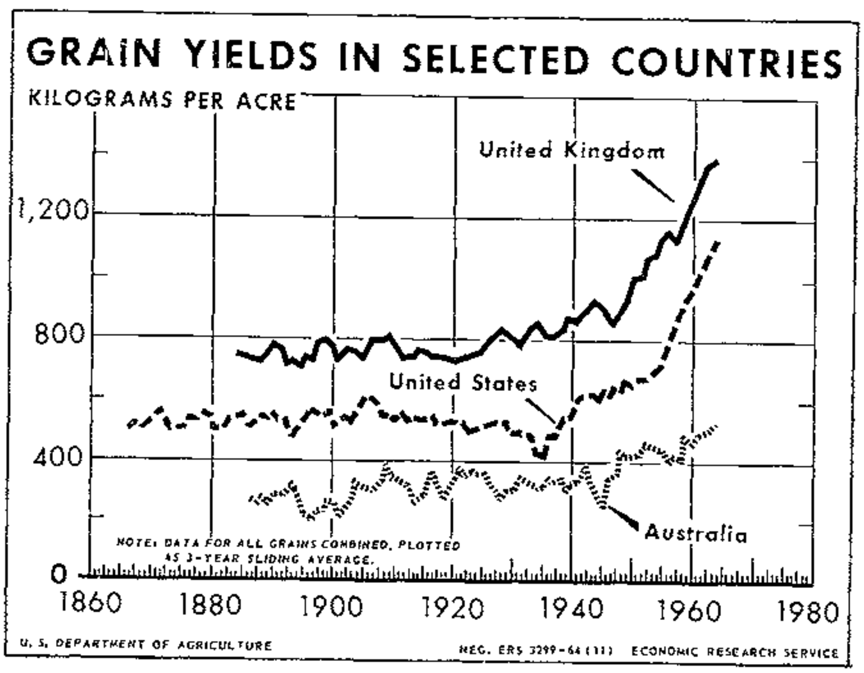

Figure 2

Grain acreage in Great Britain, averaging well over 7 million acres in the 1890's and about 6.5 million acres in the first 25 years of this century, dropped below 6 million acres in the late 1920's--beginning with 1925--then dropped further in the 1930's, averaging less than 5 million acres. Much of the acreage shifted out of grain production went into pasture, hay, and other less intensive types of cultivation. It is usually safe to assume that the land transferred from a more intensive form of cultivation to a less intensive use is below average in quality. If this assumption is valid, then the modest increases in yields during the 1925-40 period could be largely attributable to the shifting of the poorer land to less-intensive uses, and the resulting improvement in the average quality of land retained for grain.

With the advent of World War II, however, and the disruptions of the grain imports on which the United Kingdom had come to depend so heavily, it became necessary to expand output quickly.[3] Grain acreage ranging between 4.8 and 5.2 million acres throughout the 1930's jumped to 8.9 million acres by 1943. Land which had not produced grain for a long time or perhaps never, was seeded. Surprisingly, yields did not decline--they increased rapidly. The combined effect of this considerable expansion of acreage and more modest but significant rise in per acre yields was to double output.

The takeoff into a sustained trend of rapidly rising yields occurred in the United Kingdom in the early 1940's. Yields historically ranging between 700 and 800 kilograms per acre exceeded 900 kilograms in 1942 and passed 1,000 kilograms in 1949. The rise in yields occurring during the early 1940's is all the more remarkable in light of the dramatic expansion in acreage.

That the yield takeoff had occurred was evident by 1949. Yields continued the steady upward trend, reaching nearly 1,400 kilograms in 1963.

The nature of the factors contributing to the higher yields changed substantially during the 80 year period for which yield data are available. Land improvement practices, such as developing field drainage systems and removing rocks from fields, undoubtedly contributed much to the long-term gradual increases in yields characterizing the pretakeoff period.

Since takeoff, the dramatic increases in yields are probably attributable more to the rapid rise in the use of chemical fertilizer and the use of improved varieties than to anything else. Grain producers in the United Kingdom now use liberal amounts of all

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[3] The United Kingdom was dependent on external sources of food for a major share of its total grain supply.

major nutrients--nitrogen, phosphate, and potash. And fertilizer consumption, though high in comparison with many other countries, is still rising steadily.

As a result of the similarity of grain-growing conditions, a large proportion of the wheat produced in the United Kingdom consists of varieties originally developed in Germany, Belgium, Sweden, and France.

In reviewing the long-term grain yield trend for 1884 to 1963, certain things stand out. One is the tardiness of the grain yield takeoff--it was quite late, compared with both the income takeoff in the United Kingdom and the yield takeoff in other countries, notably Japan. This is undoubtedly explained by the fact that the United Kingdom was the first country to industrialize. Thus, it was able to exchange its technology, in the form of manufactures, for raw materials and foodstuffs.

Stated otherwise, it was profitable to channel resources into industry, generally neglecting agriculture, at least until World War II. Had agriculture received more attention, the yield-per-acre takeoff would undoubtedly have occurred much earlier.

A second factor is the evident importance of favorable grain prices in achieving the yield takeoff. Various government efforts to support grain prices during the latter years of the depression of the 1930's followed by the extremely favorable prices caused by the food shortages of World War II provided the incentive for the yield takeoff.

The unquestioned importance of prices in raising per acre yields during World War II, however, raises a question concerning yields during World War I. Why did not farmers respond to the extremely favorable grain prices by raising yields? Between 1915 and 1922, the average price received per bushel of wheat was at least double that of the 1910-14 period. The area in grain expanded some, but not nearly as much as in World War II. And yet grain yields did not respond at all.[4]

United States: Frontier to Takeoff

The history of grain production in the United States divides clearly into 3 periods. During the first, lasting until about 1915, grain production was increased by expanding the area; yields remained essentially unchanged. This was the frontier period. During the next period, lasting approximately from 1915 to 1940, the area in grain did not increase further, and because yields also

[4] This is discussed in more detail in Chapter VI.

failed to increase, production did not increase. The third period, dating from about 1940 to the present, contrasts sharply with the second period in that it was a period of rapidly rising yields--and therefore, rapidly rising output.

The United States provides a clear-cut, well-documented instance of a country making the transition from the area-expanding method of increasing output to the yield-raising method. Also clearly documented are the difficulties experienced by one of the world's most technologically advanced countries in attempting to make this transition.

Professor T. W. Schultz (78, p. 23), though not referring specifically to the difficulties involved in making the transition from the area-expanding to yield-raising method of increasing food output, does touch on it indirectly in discussing the difficulties involved in expanding total agricultural output during World War I.

> "Yet, once settlement had been essentially completed as it had been prior to World War I, there came a period when agricultural production hardly increased at all. The many efforts to expand agricultural production during World War I made clear that expansion was becoming difficult. The farm output of 1917-19 was only 6 percent more than that of 1910-12. The upsurge began toward the beginning of the thirties when the effects of the slowly accumulating advance of the agricultural sciences upon production was becoming significant. The investment in farm people through agricultural extension activities and more schooling made for the adoption of these modern factors and their effective use by farmers."

Not only was it difficult to expand output during World War I but it should be further noted that annual grain output during the 1910-19 decade was greater than that of either of the two following decades. Even as late as the 1938-40 period, a period of about average weather, grain production was still 1 percent below the 1910-12 average. Before examining average yield trends, it is necessary to examine indirect influences on grain yields such as trends in grain acreage, shifts in geographic location and composition of the grain production pattern. The last half of the 19th century was a period of dramatic expansion in the grain producing area, first pushing beyond the heavily settled Eastern States into the Midwestern Corn Belt region and then finally filling up the vast expanses of the Great Plains. Although the settlement of the Corn Belt somewhat preceded that of the Great Plains, the ratio between corn production and wheat production did not change greatly from the Civil War to the end of the expansion period in 1915. As a result, the average yield per acre of all grains combined also remained rather steady throughout this period.

Few countries have ever experienced an expansion of the agricultural area matching that which followed the Civil War in the United States. The area in grain had surpassed 50 million acres by 1866. During the next several years of uninterrupted expansion, the area of grain harvested doubled, exceeding 100 million acres in 1877, just 11 years later. This expansion continued until 1899 when grain acreage leveled off at about 175 million acres, and remained remarkably stable for 10 consecutive years. In 1909, acreage again began to expand, reaching 211 million acres in 1915, an area to be exceeded only a few times in the following half century.

Between 1915 and the early 1950's, grain acreage consistently ranged between 190 and 210 million acres, except in unusual years such as 1934, when severe drought reduced the area harvested below 150 million acres. Acreage restrictions and substantial increases in fallowed land resulted in a steady decline in grain acreage during the 1950's and early 1960's. By 1962, the harvested grain acreage had dropped to 151 million acres which was, with the single exception of 1934, the smallest acreage harvested since the early 1890's.

Over the 35-year span from 1866-70 to 1901-05, the area in grain nearly tripled, but yields increased less than 8 percent or at a rate of scarcely 0.3 percent per year (table 3). During the

Table 3.--United States: Change in grain yields during selected historical periods

Crop	1866-70 to 1901-05	1901-05 to 1936-40[1]	1936-40 to 1951-53	1951-53 to 1961-63
	Total change (percent)			
Corn	+5.0	+1.0	+48.5	+62.2
Wheat	+15.0	-3.6	+24.7	+43.5
Oats	+10.0	-0.7	+10.8	+32.0
Barley	N.A.	[2] +5.3	+27.4	+20.0
Rice	N.A.	[2] +37.8	+5.8	+53.3
Grain sorghum	N.A.	[3] -1.9	+47.8	+141.0
	Annual compound rate of change (percent)			
Corn	+0.1	0	+2.9	+5.0
Wheat	+0.4	-0.1	+1.6	+3.7
Oats	+0.3	0	+0.7	+2.8
Barley	--	+0.2	+1.7	+1.8
Rice	--	+1.1	+0.4	+4.4
Grain sorghum	--	-0.2	+2.9	+9.2

[1] Unfavorable weather in 1936, resulting in unusually low yields, tends to depress the 1936-40 average yield slightly.
[2] Period covered is 1909-10 to 1936-40.
[3] Period covered is 1929-30 to 1936-40.

Source: U.S. Dept. Agr. Agricultural Statistics, 1962 and 1963.

next 35 years, from 1901-05 to 1936-40, acreage increased slightly and yields declined slightly. Thus, over the 70-year period from just after the Civil War to the years immediately preceding World War II, grain yields per acre remained essentially unchanged.

But in the late 1930's and early 1940's, yields began to trend upward, rising 23 percent or 1.5 percent per year from 1936-40 to 1951-53. And this was only the beginning. During the next 10 years, 1951-53 to 1961-63, grain yields increased 59 percent, or nearly 5 percent per year.

It was noted above that neither increases in the total area in grain nor shifts in the geographic location of grain production seemed to greatly influence average yield levels (55, chapter II). Still another factor that could appreciably influence yield levels and trends would be shifts in the relative importance of various grains with widely varying yield levels.

In this respect, the most important relationship would be the ratio between the acreage in corn, by far the highest yielding grain, and the acreage in the lower yielding small grains. Corn has always dominated U.S. grain production. It accounted for close to three-fifths of the total grain acreage in the year immediately following the Civil War. This share gradually declined until it was down close to two-fifths as of the early 1960's.

This gradual decline in the share of grain acreage planted to corn would have a tendency to lower the average yield of all grains combined. Offsetting this tendency, however, was the fact that corn yields increased much more rapidly than those of the small grains such as wheat, barley, and oats. And in recent years, the expanding acreage in the high-yielding grain sorghums has also had an offsetting effect.[5]

There is no precedent in any country to the dramatic year-to-year gains in grain yields achieved in the United States during the decade from the early 1950's to the early 1960's. Each successive year from 1951 to 1963, the national average grain yield was higher than the year before, except in 1959, when it dropped back slightly. The 4.8 percent rate of annual increase, if sustained, would result in a doubling of output every 15 years. In its broadest sense, this accomplishment is the result of the unleashing of a rapidly growing, very advanced agricultural technology in the hands of highly skilled, scientifically oriented farmers. The unusually rapid increases of the past decade, however, also reflect acreage controls and the consequent intensification of land use.

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[5] Acreage in rice and rye, the 2 remaining grains, is not large enough to appreciably influence average yields of all grains combined.

There is no single factor responsible for the rapid U.S. yield increases. Rather, there are many. And they vary with individual grains. Corn seems to be the beneficiary of a large number of new and improved inputs. Among these are increasingly efficient hybrid varieties; the steadily rising rates of fertilizer application, especially nitrogen, and the use of herbicides coupled with reduced cultivation. Also contributing has been the reduction in the share of the corn crop grown in the low-yielding Southern States. The 9 percent annual rate of increase in grain sorghum yields over the past decade is due largely to the development of hybrid varieties.

Summer fallowing has become increasingly common in wheat-growing regions. In recent years, there has been at least 1 acre of land in fallow for every 2 acres of wheat. Fallowing conserves moisture in areas with low rainfall and thus contributes to higher yields and reduced chances of crop failure. But fallowing is not widely used with any grains other than wheat.

Mechanization has also contributed much to the rising yield trend. Modern farm equipment permits farmers to take advantage of good weather and minimize the effects of adverse weather. The effects of more adequate and more timely tillage, though not easily measured, have contributed to the rising yield trend. High-pressure field sprayers permit farmers to apply fungicides and insecticides with an efficiency and effectiveness not previously known.[6]

Still another important factor contributing to rapid yield increases, particularly over the past decade, have been acreage controls. Reductions in planted acreage have stimulated yield increases in 2 ways. First, land taken out of production has usually been of less-than-average quality. Second, the use of yield-raising capital inputs, such as fertilizer, has not been reduced commensurate with the reduction in acreage. The combined effect of more capital inputs per acre on land of higher average quality has been a strong boost in output per acre.

Certain things stand out in the U.S. experience. Two are dominant. The first was the great difficulty involved in making the transition from the area-expanding method of increasing food output to the yield-raising method. Two and a half decades were required to make the transition. The second point of interest concerning the U.S. experience is the dramatic rate of increase

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[6] No attempt will be made here to survey exhaustively the various factors responsible for increasing yields. The factors are discussed on an international level in Chapter IX.

in yields, once the yield takeoff was well underway. The 4.8 percent rate of annual increase prevailing in recent years is without precedent; it has never been closely approached by any other country.

Australia: A Recent Takeoff

Grain yields in Australia have been trending upward since the turn of the century. But it was not until after World War II that the takeoff occurred. From 1901-05 to 1936-40, the annual rate of yield increase was 0.5 percent per year. Much of the increase during this period, however, reflected recovery from unusually low average yields in the 1901-05 base period. Except for variations due to weather, yields remained remarkably constant from 1905-10 to 1940-45, showing no pronounced long-term trend.

After World War II, yields rose quite abruptly to a new plateau and then in the 1960's to still another plateau. The annual rate of increase from 1936-40 to 1951-53 was 2.6 percent. This dropped to 0.8 percent from 1951-53 to 1961-63, but this is probably an understatement of the progress made in developing a yield-raising capability, since the area under grain expanded some 50 percent during the 10-year period. Acreage expansions of this magnitude usually involve bringing less-than-average quality land into production. Australia is the only case-study country to generate a yield takeoff while steadily expanding the area under cultivation.

When wheat production first started in Australia, continuous cropping was practiced. Later, as wheat growing expanded inland into the lower rainfall areas and as yields began to decline on the older cultivated areas, fallowing was introduced. Wheat, accounting for four fifths of all the grain now produced in Australia, is grown in a belt fringing the continent along the southern coast. Because rainfall tends to decline with distance inland, wheat is seldom grown more than 300 miles from the coast.

Callaghan, in discussing the relationship between rainfall and the areas producing wheat, says, "The Australian wheat belt appears to have become stabilized within the areas that receive between about 9 and 15 inches of rain during the period May to October" (20, p. 34). He then observes that in regions where wheat is produced, a growing-season rainfall of about 17 inches seems to give maximum yields.

Australia's dependence on agriculture for domestic and export earnings has caused farmers to be quite conscious of yield trends. This concern over yields was noticeable as far back as the late 1890's when yields were trending sharply downward. It was discovered that the soil was generally deficient in phosphorus. Farmers began using superphosphate and succeeded not only in arresting the downward trend in yields, but in generating a modest upward trend as well.

After World War II, and particularly since 1950, the area in fallow has begun to decline, reversing a long-term trend extending well back into the last century. Several factors are responsible. Yields were declining in some parts of Australia as a result of the 2 year wheat-fallow rotation. Working the land during the fallow year to control weeds was causing a deterioration of soil structure.

Two other factors occurring concurrently--the pronounced rise in world prices of livestock products, particularly wool, and the introduction or discovery of suitable pasturing plants--have also contributed to the reduction in fallow. Wheat farmers found it economical to sow wheat land in pasture periodically for a few years. A few years in pasture often improved the soil structure and in many cases proved to be a desirable alternative to the traditional fallowing of wheat land. The area sown to grasses and clover (excluding native grasses) increased from about 20 million acres to nearly 36 million acres in 1960 (5, p. 114).

As in the other countries where yield takeoffs have occurred, favorable prices have played a key role. Since the early 1930's, when Australian farmers, like farmers elsewhere, were hard hit by declining grain prices, various efforts have been made to support and stabilize grain prices. These have included a flour tax paid by millers and used to provide relief to wheat growers, and a guaranteed minimum price, usually defined in terms of production costs, for at least a portion of the wheat exported.

In recent years (60, p. 6), a price stabilization fund, financed by the proceeds from an export tax has provided the financial wherewithal for the Australian government to guarantee prices. When the export price drops below the guaranteed price, funds are appropriated directly for deficiency payments to growers.

India: When Will The Takeoff Occur?

India is the only case-study country that has not yet achieved a yield takeoff. Grain yields declined between 1936-40 and 1951-53, then trended upward from 1951-53 to 1961-63. But the gains recorded during the last decade were not all real gains, but gains partly, and perhaps largely, associated with postwar and post-partition recovery.

Grain yields per harvested acre averaged 296 kilograms per acre during 1901-05; 277 kilograms from 1956 to 1960; and 305

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kilograms from 1961 to 1963. Yields during 1956-60 were below those of 1901-05. But from 1901-05 to 1961-63, a 59-year period, they increased 3 percent.[7]

India's grain production pattern is more varied than that of the other case-study countries. Rice is the grain produced in greatest quantity, but it accounts for well below half of total grain output. Wheat ranks second. After wheat come several minor grains, including corn, barley, and various types of millets such as jowar, bajra, and ragi. All grains produced in India are food grains since grain supplies are too meager to permit much feeding to livestock.

Irrigation figures more prominently in grain production than in any of the other case-study countries, except Japan. Most of the rice acreage in India and about a third of the wheat acreage is irrigated.

The millets are grown in low-average rainfall areas with dry-land farming techniques. Yields of the millets, especially jowar and bajra, average only 150-200 kilograms per acre--scarcely half the yield levels of rice and wheat.

Indian agriculture is strongly influenced by the seasonal distribution of annual rainfall. Three-fourths of the annual rainfall comes during the monsoon period from June to September. The remaining one-fourth falls mostly during the periods immediately preceding and following the monsoon, leaving 5-7 months with virtually no rain at all. Improved practices such as methods of planting, tilling, and fertilizing must take into account the heavy rains of the monsoon as well as the long, dry period that follows.

The problems facing Indian agriculture as it attempts to achieve a yield takeoff are formidable. Research on grain production and seed improvement is much more costly in India than elsewhere because of the large number of grains produced. Whereas Australia can concentrate its research efforts on wheat and Japan on rice, India must distribute its limited research resources among several grains.

In addition to the complications associated with the need to have several major research programs--one for each grain--the results must be translated and published in several different languages. States in India are organized along linguistic lines, each of the 16 States having a different language. And beyond this, most of the major languages break down further into several

[7] The practice of multiple cropping in India, though not very widespread, has become more common in recent years, due largely to the increased availability of water for irrigation during the dry season. Thus, output per acre of cropland has been rising slightly more than output per crop acre harvested.

dialects. Thus, if results of research conducted in one State are to be useful elsewhere they must be translated and published in the languages of other States.

Native varieties, although well adapted to local soil and climatic conditions, often do not respond well to fertilizer. Varieties introduced from the United States or Japan quite often respond to fertilizer, but do not adapt well to local conditions.

But perhaps the greatest single handicap is the difficulty encountered in getting information to farmers. India, though having a cultivated land area of about 350 million acres--about the same as the United States--has 60 million farmers, compared with fewer than 4 million in the United States. Thus, to cover the same area of farmland, Indian extension workers must work with 60 million largely illiterate farmers. How effective would the highly trained, proficient agricultural extension service of the United States be under similar circumstances?

Still another problem facing Indian agriculture is the low level of incomes and consequent lack of capital for investment in agriculture. Incomes that are always near the subsistence level make capital accumulation difficult. As a result, land and labor are the principal inputs. Capital inputs are usually limited to items such as seed, tillage implements, and bullocks to draw the implements. Only a very small share of India's 60 million farmers have ever used such agricultural chemicals as fertilizer, insecticides, or fungicides.

Grain yields in India today are quite low by international standards. During the 1961-63 period, average grain yields were less than one fourth those in more advanced countries such as Japan or the United Kingdom. Grain yields, though showing a tendency to rise in recent years, have changed little over the 6-decade period for which data are available.

Summary of Yield Trends

Long-term yield trends in the case-study countries, varying in length from 68 years in India to 98 years in the United States, show quite clearly the existence of the yield per acre takeoff phenomenon. Long-term yield trends can be divided into two phases or stages--the pretakeoff stage and the posttakeoff stage. The pretakeoff stage is characterized by near-static yield levels; the posttakeoff stage by steadily rising yields.

Evidence indicates that yield takeoffs are not easily achieved, even in economically advanced countries. Once underway, however, yield takeoffs appear to be irreversible except in time of war or some similar disaster. And thus far all have continued indefinitely--the rising yield trends have not leveled off or shown any tendency to level off. Japan's steadily rising yield trend has continued unabated, except during World War II and the subsequent recovery period, for the better part of a century.

The yield takeoff, as an agricultural phenomenon, appears to have the same definable characteristics whether it be in a semi-arid wheat-producing economy such as Australia, a high-rainfall, rice-producing economy such as Japan, or a highly diversified, grain-producing economy such as the United States.

Each of the case-study countries except India has experienced a yield takeoff. Japan, the first of the group to do so, managed its takeoff during the last quarter of the 19th century. It was more than half a century later--near the middle of the 20th century--before the other case-study countries, the United Kingdom, the United States, and Australia, were able to generate yield takeoffs.

Japan's experience differs substantially from the other case-study countries in that its takeoff took place at a very early stage of economic development. The United Kingdom, United States, and Australia were quite advanced at the time of yield takeoff. Australia differed from the other countries in that it had not nearly exhausted the supply of cultivable land at the time of its takeoff.

The annual rate of yield increase since takeoff varies widely among countries. Japan, which initiated its takeoff at a very early stage of development, has consistently maintained an annual compound rate of increase of between 1 and 2 percent. Australia, the United Kingdom, and the United States, achieving takeoff much more recently and at a much later stage of development, have maintained considerably higher rates of annual yield increase. Rates of increase for the 3 countries respectively, from 1938-40 to 1961-63, a period roughly coinciding with their yield takeoffs, are 1.9, 2.1, and 2.8 percent.

Chapter IV.--RELATIONSHIP BETWEEN INCOME TAKEOFF AND YIELD TAKEOFF

The relationship between the takeoffs in income per person and in yield per acre has received little attention in the past, and understandably so. Limitations on the supply of cultivable land did not pose a major problem for those countries which industrialized earlier. The early developing countries of Europe could, when faced with pressure of population on the land, trade their manufactures with the rest of the world for foodstuffs and raw materials. And if this was not sufficient, population pressure could be relieved by emigration to the New World, Australia, New Zealand, or other sparsely settled regions.

Others in the first group of countries to industrialize were the newly settled countries, such as the United States, Canada, Australia, and New Zealand. Those countries were well on the way to industrialization before their supplies of cultivable land were exhausted. Stated otherwise, these countries experienced an income takeoff long before it was necessary to start raising yields in a rapid, sustained fashion.

But those countries attempting to initiate development today do not have a technological advantage over the rest of the world. Possibilities of large-scale emigration to relieve population pressure no longer exist. And in most of today's less-developed countries, frontiers have long since disappeared.

Thus, given no appreciable opportunity for expanding the cultivated area, given continuing dependence on indigenous agriculture for the food supply, and given the current unprecedented rates of population growth, the essentially "fixed-land," less-developed countries are faced with these alternatives:

(1) Achieving a yield takeoff with annual increases approximating annual population increases.

(2) Accepting a decline in per capita food output and an eventual rise in the death rate as a result of severe malnutrition or starvation.

(3) Becoming increasingly dependent on food produced in developed countries and supplied on concessional terms.

Most of the less-developed countries attempting to develop today do not have much new land available for cultivation; they are dependent on traditional agriculture for their food supply; and they do have population growth rates of 2 to 3 percent per year. If these countries do not succeed in generating a yield takeoff, the alternatives--declining per capita food output or increasing dependence on external sources of food--are, at best, not conducive to development, and either alternative could forestall an income per person takeoff for the indefinite future.

Thus, an understanding of the relationship between the income-per-person takeoff and the yield-per-acre takeoff is essential to understanding the problems confronting the great majority of countries now attempting to industrialize.

Usual Sequence of the Two Takeoffs

Australia, Japan, the United Kingdom, and the United States have experienced a takeoff in both income per person and yield per acre (table 4). The income takeoff substantially preceded the yield takeoff in each of these countries, except Japan, where the 2 takeoffs appear to have occurred simultaneously (fig. 3).

Table 4.--Estimated dates of income per person takeoff and yield per acre takeoff in case-study countries [1]

Country	Income per person takeoff	Yield per acre takeoff
United Kingdom..........	1783-1802	1937-1954
United States...........	1843-1860	1938-1956
Japan...................	1878-1900	1880-1900
Australia...............	1910-1925	1946-1963
India...................	?	?

[1] Income takeoff dates are from Rostow (77, p.38) except that for Australia, which is author's. Yield takeoff dates are author's.

Considerable variation exists as to the time lapse between the 2 takeoffs. The time lapse was longest in the United Kingdom, where a century and a half separated the 2 takeoffs. The 2 takeoffs were nearly a century apart in the United States and about 4 decades apart in Australia.

The United Kingdom, the first country to experience an income takeoff, was able to postpone the yield takeoff for several reasons. Chief among these was the fact that it was more profitable for the

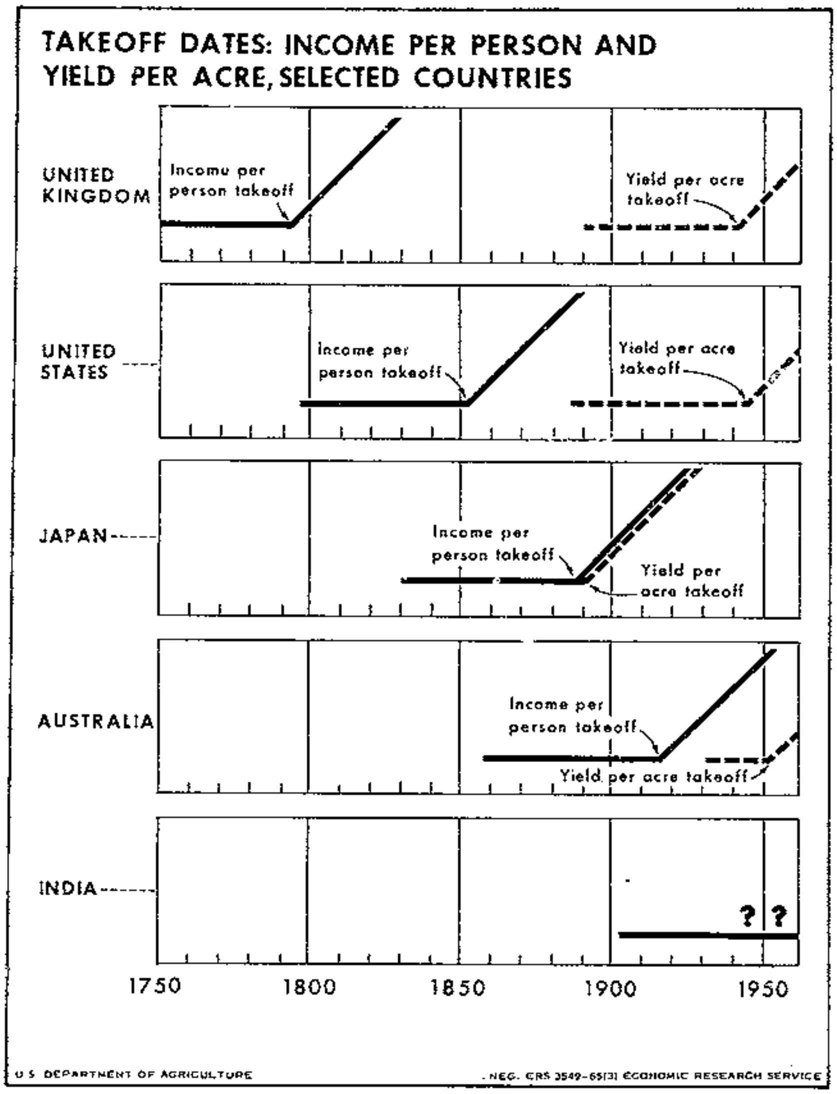

Figure 3

United Kingdom to capitalize on its early technological lead by exporting manufactured goods and importing foodstuffs and raw materials. Also, opportunities for emigration to the New World, Australia, and New Zealand were almost unlimited.

Thus, the United Kingdom, though it achieved an income takeoff in the latter part of the 18th century, did not generate a yield takeoff until the outbreak of World War II. An effort to generate a yield takeoff during World War I, when food was in short supply, met with no success.

The income takeoff in the United States occurred in the middle of the 19th century--just before the Civil War. At this time there were still vast areas of cultivable land awaiting settlement; there was no need for a yield takeoff. But by 1915, the supply of new land was virtually exhausted. It was not until the oubreak of World War II, however, that yields began to rise. Nearly a century elapsed between the 2 takeoffs.

Australia's income takeoff preceded its yield takeoff by about 4 decades. Australia's case is unique in that its yield takeoff occurred while the area under cultivation was still expanding. This concentration of effort on raising yields might reflect, more than anything else, the less-than-average quality of the land being brought under cultivation.

Japan's experience in generating the income takeoff and the yield takeoff at the same time is unique among the countries to industrialize early. It should be noted, however, that simultaneous or near-simultaneous takeoffs may become the rule rather than the exception in the countries now trying to develop.

Interdependence of the Two Takeoffs

The income-per-person takeoff and the yield-per-acre takeoff were rather independent of each other in most of the countries that are now highly industrialized. But for those countries struggling to develop today--where the cultivable land supply is essentially fixed and where possibilities for large-scale emigration are nonexistent--the relationship between the 2 takeoffs is quite different.

Those less-developed countries that have nearly exhausted the supply of cultivable land before generating a per capita income takeoff will find both the income and yield takeoffs much more difficult. The longer the lapse between the time of the income takeoff and the time when a yield takeoff is needed, the easier it is to achieve a yield takeoff and the more rapid the rate of yield increase after takeoff is likely to be.

At this point, it is useful to ask 2 questions concerning the relationship of the 2 takeoffs in less-developed, fixed-land economies now attempting to industrialize. Can a yield-per-acre takeoff occur in the absence of an income-per-person takeoff? And, conversely, can an income-per-person takeoff occur in the absence of a yield-per-acre takeoff? The answer to both questions is probably no.

There is considerable evidence in both this chapter and chapter VI indicating that a less-developed, fixed-land economy not experiencing an income-per-person takeoff will find it very difficult, if not impossible, to attain a yield-per-acre takeoff. But the converse is also true. As long as the number of people in agriculture is still increasing, an income takeoff is not likely to occur in a fixed-land economy in the absence of a yield takeoff.

Ogura (69, p. 618), in discussing the Japanese experience and its relevance to other Asian countries, says, concerning the numbers dependent on agriculture:

> "At the same time, however, the tempo of population growth today is often so fast--faster than that experienced by Japan--and the problem of finding employment for the growing work force so great, that these countries can seldom countenance methods of raising agricultural productivity which involve a marked reduction in the size of the rural population. On the contrary it is probable that as a rule the number of people dependent on agriculture for employment will increase for some decades to come."

If a less-developed economy nearly exhausts its supply of cultivated land before it achieves a takeoff in yield per acre then, in addition to being faced with either a decline in per capita food output or increasing dependence on external sources of food, it may well experience a decline in the labor productivity of the rural population. Given, on the one hand, the essentially fixed area of cultivated land and the inability to generate a yield takeoff, and on the other, the continuing growth in the number of people dependent on agriculture for their livelihood, a decline in the productivity of agricultural labor is inevitable. If per capita productivity or income is declining for a major part of the population, then the prospects for generating an income takeoff for the entire population are seriously diminished.

Most of the less-developed countries are today facing the situation that Japan faced in the latter part of the last century. Faced with intense pressure of population on the land and lagging technology, today's less-developed countries have a seriously reduced range of alternatives. Japan had to generate an income-per-person takeoff and a yield-per-acre takeoff simultaneously. So, too, will many of the countries attempting to develop today.

Chapter V.--SOME FACTORS FACILITATING THE YIELD TAKEOFF[1]

There are certain identifiable differences between those countries in which yields are essentially static and those in which they are rising in a rapid, sustained fashion. This Chapter examines some of the major differences. The 4 selected for discussion are broad, generally economic, factors. They deal with literacy, income, the market orientation of agriculture, and the nonagricultural sector of the economy.

These factors are to a certain extent substitutable. A country with a relatively high level of income, for instance, may be able to afford the higher cost of disseminating new farming techniques that are usually associated with low levels of literacy. It will thus be able to generate a yield takeoff with a lower level of literacy than would otherwise be the case.

Measures can be taken to compensate at least partially for shortcomings in any 1 of the 4 factors. A country with a relatively low level of income but a high rate of savings may still be able to accumulate enough capital to purchase yield-raising inputs and generate a yield takeoff. Such may have been the case in Japan, where the yield takeoff occurred during the latter part of the last century when income levels were still quite low.

The inability of the nonagricultural sector of the economy to supply the goods and services required to raise yields may be compensated for by importing many of the goods and perhaps some of the services. Fertilizer, for example, is often imported during the early stages of development. This represents a drain on limited foreign exchange reserves but, given the need to raise yields, there may not be any practical alternative.

Services such as research and credit cannot be imported as readily. Adaptive research using the basic research results developed in more advanced countries and adapting them to local conditions must be done within the country.

The minimal level of development of any one of these 4 factors required for a yield-per-acre takeoff may vary widely between countries. The minimal level may vary with any one of many other

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[1] See Preface for discussion of the relationship between the term "preconditions" used by Rostow and the terminology used in this study.

factors, including the type of agriculture, social systems, land-man ratio, soil fertility, and climatic conditions. Since the minimal level of development of each factor required for a yield takeoff varies among countries, no effort will be made to specify a general minimum for all countries.

The Level of Literacy

Definitions of literacy vary as do tests of literacy, giving rise to the terms "formal literacy" and "functional literacy." Some tests reflect only reading ability, others both reading and writing ability. The minimum age on which literacy rates are based usually varies from 5 to 10 years of age but may be applied to the total populace, including infants.

Literacy is usually higher in urban than in rural areas. A society, which is 70 percent literate overall may be 90 percent literate in urban areas, but only 60 percent literate in rural areas. Literacy rates are also invariably higher among males than among females. Literacy differences between sexes are usually more pronounced in less-developed societies.

Progress in eradicating illiteracy, particularly in the early stages, is often painfully slow. But like many other phenomena, the growth of literacy seems to be self sustaining once well underway (figs. 4-6). Literacy trends by country show that once a certain minimal level of literacy is attained, usually between one-fourth and one-third, that it is only a few decades until the population becomes largely or almost entirely literate. A lingering small percentage of illiteracy often indicates a concentration of illiteracy in some specific group or locale.

Literacy (tables 5 and 6) has a key role in the development process It provides both general and specific benefits; it broadens the range of contact and expands the range of stimuli to which an individual is exposed. Ideas, particularly complicated ones, move with painful slowness when they are dependent on oral media. Too, it is difficult to transmit complex ideas very far with any degree of accuracy.

Professor Schultz describes the importance of literacy in disseminating information (79, p. 202).

> "...the costs of producing and distributing new technical and related economic information to farm people are reduced very substantially when published materials can be used. When farm people are effectively literate, farm journals and the press generally become important vehicles of information. An agricultural extension service can then also use bulletins,

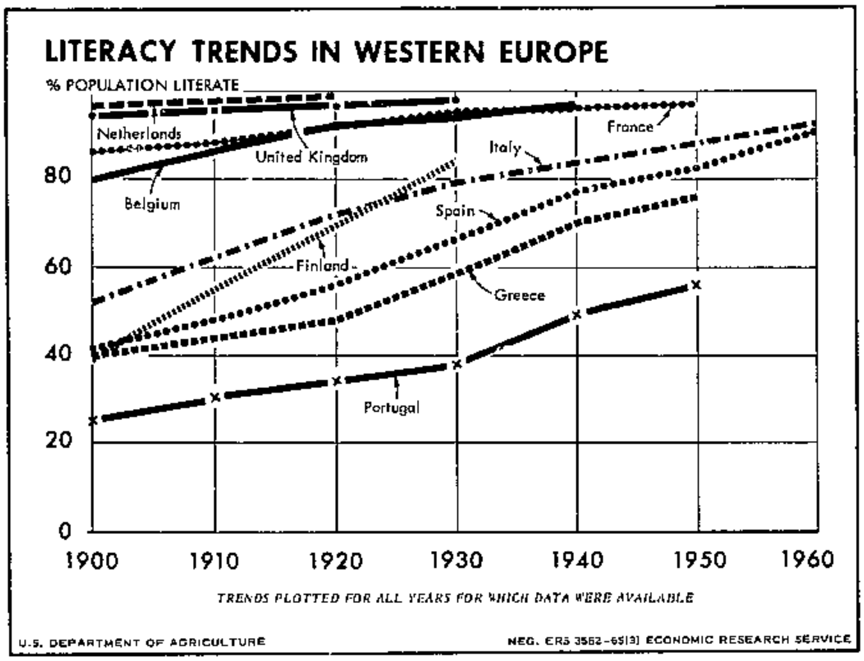

Figure 4

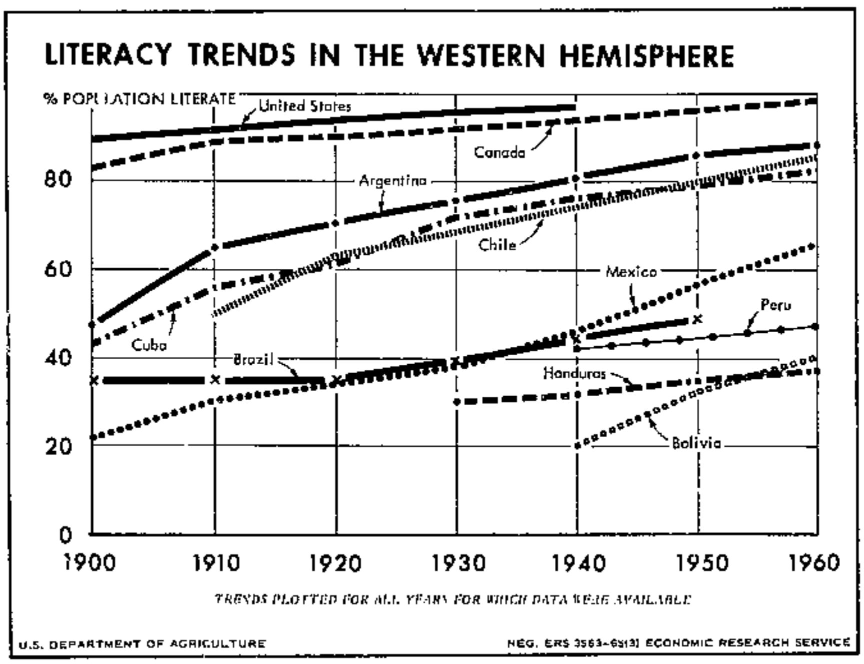

Figure 5

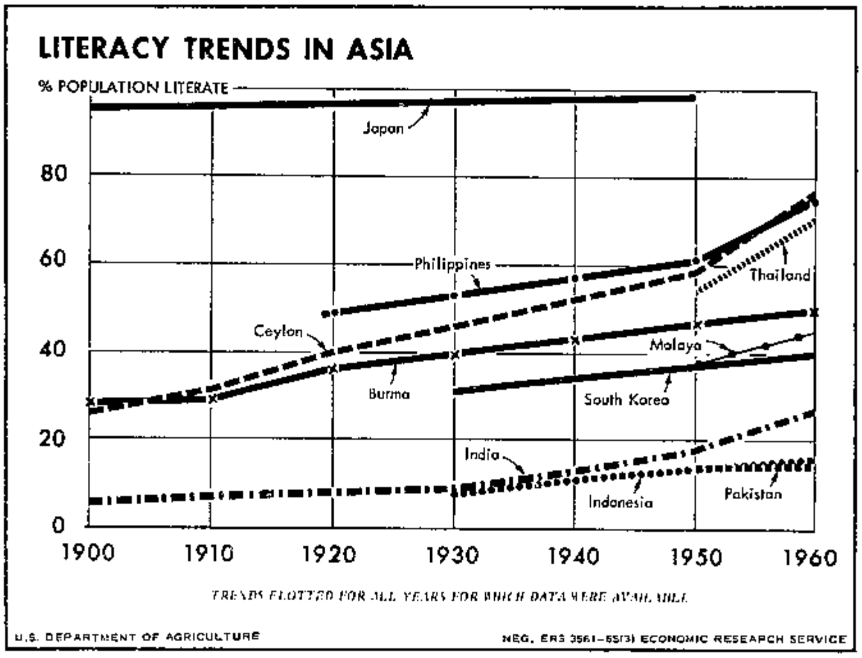

Figure 6

pamphlets, and printed instructions, which are for many purposes much cheaper than meetings with farmers based wholly on oral presentations."

The Encyclopedia of Social Sciences in discussing the early spread of literacy through Northwestern Europe, touches upon the usefulness of literacy in the modern economy (37, p. 511f).

> "...the most notable extension of literacy in the early centuries of the modern era took place among the middle classes and was at first associated with the capitalistic revolution, the development of foreign trade, the improvement in systems of accounting, and the repeated verification of the causative connection between pertinent information and economic rewards."

A cost-profit calculus is nearly impossible for a farmer unable to keep records and make simple calculations. To such farmers, additional expenditures for a new improved input, such as hybrid seed or fertilizer, are simply an additional expense with some immeasurable sort of reward. There is no convenient way for the illiterate farmer to link inputs made at planting time with harvest or sales made many months hence.

Literacy levels vary widely by geographic regions, and they are higher for the developed regions than for the less-developed

Table 5.--Literacy levels: Estimates for selected countries in North America, Western Europe, Eastern Europe, and Oceania, 1900-1960[1]

Region and country	About 1900	About 1910	About 1920	About 1930	About 1940	About 1950	About 1960
	- - - - - - - - - - - -	- - -	Percent literate	- - -	- - -	- - -	- - -
North America							
Canada...........	83	89	90	92	--	--	98
United States.....	89	92	94	96	97	--	--
Western Europe							
Belgium..........	80	86	92	94	97	--	--
England..........	94	--	--	([2])	--	--	--
Finland..........	39	55	70	84	--	--	--
France...........	86	88	92	95	96	97	--
Greece...........	40	--	48	59	70	76	--
Italy............	52	--	72	79	--	--	92
Netherlands.......	96	--	99	([2])	--	--	--
Portugal..........	25	30	34	38	49	56	--
Spain............	41	48	56	--	77	83	90
Sweden...........	--	--	99	([2])	--	--	--
Eastern Europe							
Bulgaria..........	30	42	53	69	--	--	89
Hungary...........	61	69	85	90	93	95	99
Poland............	--	--	67	77	--	--	90
Rumania...........	11	--	55	--	--	77	85
Soviet Union......	--	30	57	--	81	--	98
Yugoslavia........	40	--	50	53	--	75	80
Oceania							
Australia.........	80	84	85	--	97	--	--

[1] Figures are unadjusted for changes in geographic boundaries. Data from before World War II for Finland and the Soviet Union, for instance, pertain to prewar boundaries. Neither are figures adjusted for variations in definitions within a given country over time or between countries. Literacy is usually defined as the ability to read or write, but sometimes it means simply the ability to read. Age groups covered may vary from the total population to age 15 and up. Most often estimates apply to the population 10 years of age and up.

[2] Illiteracy practically unknown after this time. At this point in a country's educational development, the census questionnaire question "Can you read and write?" is often replaced by the question "How many years of schooling have you had?"

Source: Principal among the numerous sources used was Progress of Literacy in Various Countries (UNESCO) (88) and the Demographic Yearbooks for 1948 and 1955 (86). Other sources were (35; 36; 37).

regions. The populations of North America, Western Europe, and Oceania are almost entirely literate. Eastern Europe's level of literacy is high but probably not much above 90 percent.

Data for major countries in Asia indicate a regional level of literacy not much above one third. Incomplete data for Africa show a level of literacy even less than one third. The overall level of literacy in Latin America, the third less-developed region, is much higher, probably two-thirds or more.

Table 6.--Literacy levels: Estimates for selected countries in Asia, Africa and Latin America, 1900-1960[1]

Region and country	About 1900	About 1910	About 1920	About 1930	About 1940	About 1950	About 1960
	- - - - -	- - - - -	- - - - -	Percent literate	- - - - -	- - - - -	- - - - -
Asia							
Burma	28	29	36	40	--	--	50
Ceylon	26	31	40	--	--	58	76
China, Mainland	--	--	--	--	--	30	--
India	6	7	8	9	--	18	27
Indonesia	--	--	--	8	--		16
Japan	95		--	--	--	98	--
Korea, South	--	--	--	31	--	--	40
Malaya, Fed. of	--	--	--	--	--	38	45
Pakistan	--	--	--	--	--	14	15
Philippines	--	--	49	--	--	61	75
Thailand	--	--	--	--	--	54	70
Africa							
Congo (Leopoldville)	--	--	--	--	--	37	--
Egypt (UAR)	7	10	14	15	--	22	30
Ghana	--	--	--	--	--	10	--
Liberia	--	--	--	--	--	--	10
Nyasaland	--	--	--	--	7	--	--
Tanganyika	--	--	--	--	--	--	10
South Africa, Rep. of	--	--	10	--	--	30	40
Uganda	--	--	--	--	--	30	--
Latin America							
Argentina	47	65	--	--	--	86	88
Brazil	35	--	35	--	44	49	--
Bolivia							
Chile	--	50	63	--	74	--	85
Colombia	--	--	42	52	56	--	--
Cuba	43	56	61	72	76	--	82
Honduras	--	--	--	30	32	35	37
Mexico	22	30	34	38	46	57	65
Peru	--	--	--	--	42	--	47
Venezuela	--	--	--	--	43	49	82

[1] Figures are unadjusted for changes in geographic boundaries. Data from before World War II for India, for instance, pertain to prewar boundaries. Neither are figures adjusted for variations in definitions within a given country over time or between countries. Literacy is usually defined as the ability to read or write, but sometimes it means simply the ability to read. Age groups covered may vary from the total population to age 15 and up. Most often estimates apply to the population 10 years of age and up.

Source: Principal among the numerous sources used was Progress of Literacy in Various Countries (UNESCO) and the Demographic Yearbooks for 1948 and 1955. Other sources were (35, 36, 37).

Even more discouraging than the current low levels of literacy in the less-developed regions, however, is the lack of progress in eliminating illiteracy (table 7). United Nations estimates for

Table 7.--Estimated school-age population and pupil enrollment at the first (primary) level of education in the major less-developed regions of the world, about 1960

Region	Estimated school-age population	Estimated pupil enrollment	Proportion of school-age children enrolled
	Millions	Millions	Percent
Africa (35 countries).......	29.4	11.2	38
Arab States (15 countries)..	13.3	6.5	49
Asia (15 countries).........	130.1	66.2	51
Latin America (20 countries)	33.2	26.1	79
Total (85 countries)..	206.0	110.0	53

Source: (90).

1960 (90) indicate that in Asia only 51 percent of the primary-school-age children were enrolled in school (table 7). For Africa, the proportion in school was estimated at 38 percent; in Latin America, it was estimated at 79 percent. Clearly, where the percentage of children in school is as low as in Asia and Africa, near-universal literacy is still far in the future. It will be several years before all school-age children are in school, and then many years after that before illiteracy in the older, unschooled groups is eradicated. Barring the development of widespread adult education programs, a large proportion of the population in Asia and Africa seems destined to remain illiterate a few more decades at least.

The following section investigates the relationship between change in yield per acre of rice during the period from 1934-38 to 1960-62 and the level of literacy in each of the 13 major rice-producing countries. Subsequent sections do the same for the 27 major wheat-producing countries and the 23 major corn-producing countries.

Literacy and Rice Yields

Rice is the principal food staple in 5 of the world's 7 most populous countries--China, India, Pakistan, Indonesia, and Japan. These countries contain half the world's people, and in each country, rice supplies one third to one half of all calories consumed. In each country except Japan, calorie intake levels are well below minimal nutritional requirements. Yet despite the overwhelming dependence on rice and the lack of new land suitable for growing rice, only limited progress has been made in raising per acre yields.

Literacy levels are low in most rice-producing countries. Of the 13 major rice-producing countries (1 million acres or more in rice), only 2, Japan and the United States, have near-universal literacy (fig. 7). Only 2 of the 11 remaining countries have populations that are more than 50 percent literate. Three of the major producers--India, Pakistan and Indonesia--have literacy rates of only 15 to 25 percent. This lack of literacy, which limits the diffusion of new ideas and techniques, is undoubtedly one reason for the slow gains in rice yields that characterize most rice-producing countries.

Rice yields increased in 11 of the 13 major producing countries over the 24 years between 1935-39 and 1960-62, but at modest rates (table 8). No country achieved a rate of gain greater than 1 percent per year except Japan and the United States, both highly literate. For several leading producers, such as India, Indonesia, Pakistan, and Brazil, the rate of increase was less than 0.5 percent per year.

Yields actually declined in two countries--Thailand and the Malagasy Republic. This is not too surprising in the Malagasy Republic, because the population is less than one third literate. Thailand, however, has a rather high level of literacy, especially when compared with many other rice-producing countries, and

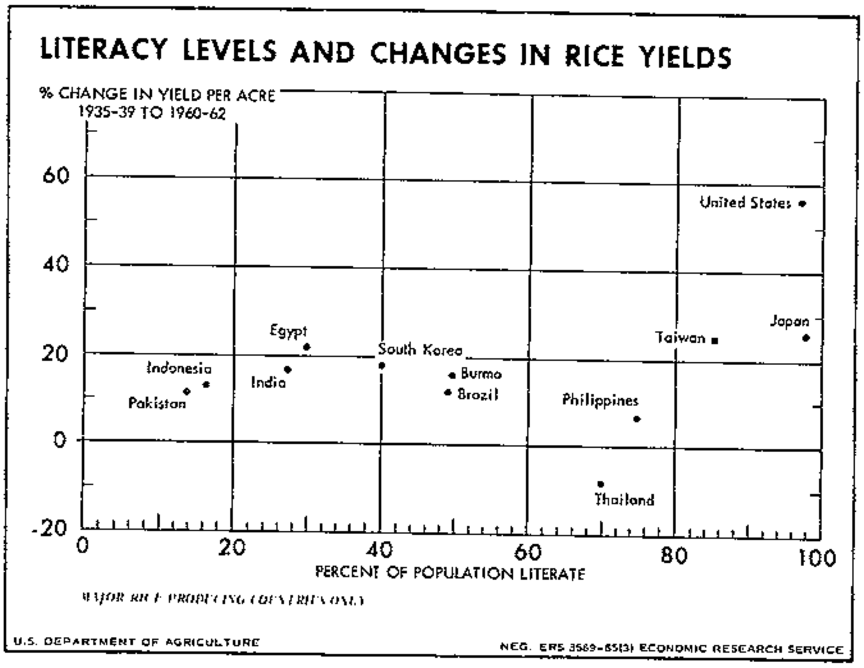

Figure 7

Table 8.--Rice yields in major producing countries: Change from 1935-39 to 1960-62[1]

Country	Yield per acre[2]		Change from 1935-39 to 1960-62[4]	Annual compound rate of change
	1935-39	1960-62[3]		
	Cwt.	Cwt.	Percent	Percent
United States......	22.4	35.0	+56	+1.9
Brazil.............	12.9	14.4	+12	+0.5
U.A.R. (Egypt).....	32.2	39.4	+22	+0.8
Malagasy Republic..	12.7	12.1	-5	-0.2
Burma..............	12.4	14.4	+16	+0.6
China (Taiwan).....	23.8	29.7	+25	+0.9
India..............	11.6	13.6	+17	+0.7
Indonesia..........	[5] 14.4	16.2	+13	+0.5
Japan..............	34.1	43.1	+26	+1.0
Korea (South)......	[6] 23.0	27.1	+18	+0.7
Pakistan...........	13.0	14.6	+12	+0.5
Philippines........	9.7	10.4	+7	+0.3
Thailand...........	13.5	12.4	-8	-0.3

[1] Major producing countries are those having 1 million acres or more in rice. [2] In terms of rough rice. [3] For several countries, 1962 data were not yet available; so average is for 2 years only. [4] Percentage change calculations based on unrounded yield figures. [5] 1935-39 data for Java and Madura only. [6] 1935-39 data for prepartition Korea.

Source: U.S. Dept. Agr. Agricultural Statistics, 1949, 1962, and 1963.

presumably should have been able to raise yields substantially. Thailand, faced with a steadily growing population, nearly doubled its rice acreage between 1935-39 and 1960-62. And, as is often the case, most of the better rice land was already in production before World War II. Land brought under cultivation in recent years has often been of less than average quality.

The United States, with its highly literate, scientifically oriented farm population, raised rice yields 56 percent over the 24-year period. This was nearly twice as much as in Japan, the second most successful country in terms of rate of yield increase. Clearly, a high level of literacy makes a yield takeoff much easier.

Professor Schultz reaches similar conclusions concerning the role of literacy in raising rice yields (77, p. 187):

> "The new combination of inputs that accounts for the large increases in rice yields in particular countries, notably in Japan, have not been adopted by rice growers in those countries where the farm people who grow rice are predominantly illiterate."

Literacy and Wheat Yields

Not one of the 25 major wheat-producing countries (2 million acres or more of wheat) with a low level of literacy was able to raise yields significantly during the quarter century between the late 1930's and the early 1960's (table 9). Average yields of wheat per acre actually declined in Tunisia and Brazil, both countries with low literacy levels.

A high level of literacy seemed to be a necessary precondition for raising yields (fig. 8). But it was not in itself sufficient; it did not guarantee pronounced gains in yields.

Some countries, such as Bulgaria, Spain, or the Soviet Union, with literacy levels ranging above 80 percent, made little or no

Table 9.--Wheat yields in major producing countries: Change from 1935-39 to 1960-62[1]

Country	Yield per acre		Change from 1935-39 to 1960-62	Annual compound rate of change
	1935-39	1960-62		
	Bushels	Bushels	Percent	Percent
Canada	12.2	[2] 20.9	+71	+2.3
United States	13.2	25.1	+90	+2.7
Argentina	14.0	17.6	+26	+1.0
Brazil	10.5	[3] 10.3	-2	-0.1
Chile	16.1	19.7	+22	+0.8
Mexico	11.5	25.3	+120	+3.3
France	22.8	39.6	+74	+2.3
Germany (West)	[4] 34.6	49.3	+42	+1.5
Greece	14.0	22.5	+61	+2.0
Italy	22.1	27.0	+22	+0.8
Spain	14.0	14.8	+6	+0.2
United Kingdom	33.8	54.8	+62	+2.0
Bulgaria	20.5	21.0	+2	+0.1
Hungary	22.3	26.3	+18	+0.7
Poland	22.7	27.0	+19	+0.7
Rumania	16.2	18.8	+16	+0.6
Yugoslavia	18.1	23.8	+31	+1.2
Soviet Union	11.9	11.9	0	0
Algeria	8.4	[3] 10.0	+19	+0.7
Morocco	7.1	9.4	+32	+1.3
Tunisia	7.8	5.5	-30	-1.1
South Africa	8.3	10.0	+20	+0.8
Iraq	10.7	[3] 10.7	0	0
Turkey	15.1	15.6	+3	+0.1
India	[5] 10.7	12.4	+16	+0.6
Pakistan	[5] 10.7	12.1	+13	+0.5
Australia	12.9	18.4	+43	+1.5

[1] Major producing countries defined as those having 2 million acres or more of wheat. [2] 1961 omitted from average because of abnormal weather conditions. [3] 1955-59 data used because later data not available or abnormal conditions such as war prevailed. [4] 1935-39 data are for prewar boundaries. [5] 1935-39 data are for prepartition India.

Source: U.S. Dept. Agr. Agricultural Statistics, 1949, 1962, and 1963.

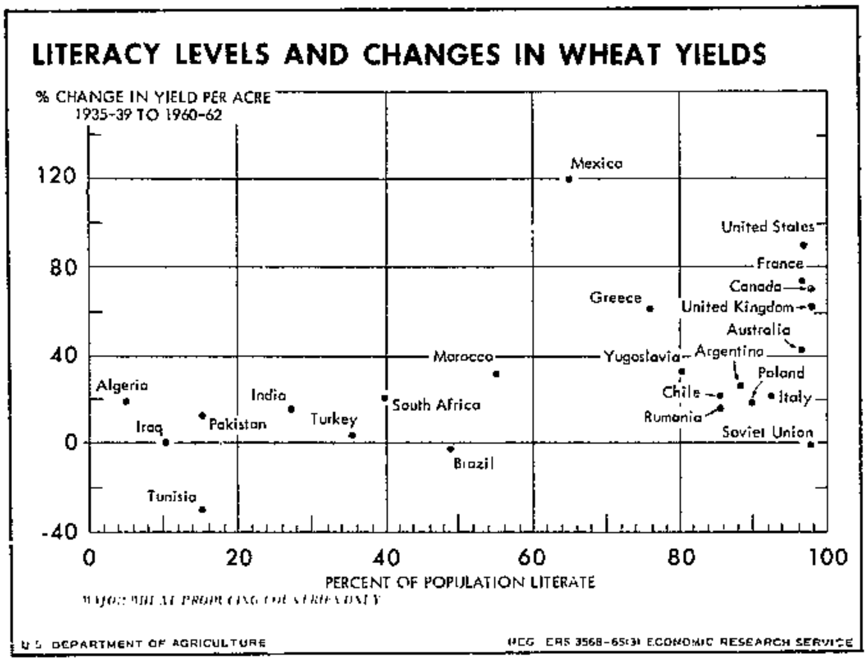

Figure 8

progress in raising yields. Countries making the most progress in raising yields were in general those which have had near-universal literacy for several decades. Mexico and Greece are the principal exceptions.

In Mexico, the outstanding progress in raising wheat yields was partly the result of shifting a large share of the wheat acreage onto irrigated land. The availability of water for growing wheat has in turn made the use of sizable applications of chemical fertilizer profitable. In addition to water and fertilizer, improved varieties of wheat developed with the assistance of the Rockefeller Foundation have contributed much to the impressive Mexican gains in yields. Government-sponsored irrigation projects also contributed to the higher yields in Greece. It should be noted, however, that large-scale expansion of the wheat area under irrigation, a key factor in raising wheat yields in Mexico and Greece, is not possible in most wheat-growing countries.

Four of the 6 countries to sustain a rate of increase of 2 percent or more per year--Canada, France, the United Kingdom, and the United States--have had near-universal literacy for several decades. In both Mexico and Greece, most of the progress made in eradicating illiteracy has been quite recent, and though the populations of both countries are largely literate, a significant amount of illiteracy still persists in rural areas.

Literacy and Corn Yields

Changes in corn yields per acre between 1935-39 and 1960-62 in major corn-producing countries (1 million acres or more) ranged from a decline of 28 percent, or 1 percent per year, in Guatemala to an increase of 141 percent or 3.7 percent per year in the United States (table 10). Only 25 percent of Guatemala's population can read and write, whereas the U.S. population is almost entirely literate.

Table 10.--Corn yields in major producing countries: Change from 1935-39 to 1960-62[1]

Country	Yield per acre		Change from 1935-39 to 1960-62	Annual compound rate of change
	1935-39	1960-62		
	Bushels	Bushels	Percent	Percent
Canada..............	40.8	68.7	+68	+2.2
United States.......	25.0	60.2	+141	+3.7
Argentina...........	28.0	[2] 29.9	+7	+0.3
Brazil..............	21.5	[2] 20.8	-3	-0.1
Colombia............	[4] 15.1	17.7	+17	+0.7
Guatemala...........	15.7	[3] 11.3	-28	-1.0
Mexico..............	9.0	13.7	+52	+1.8
France..............	26.9	42.8	+59	+2.0
Italy...............	31.5	46.8	+49	+1.7
Portugal............	12.1	20.0	+65	+2.1
Spain...............	[4] 28.4	36.9	+30	+1.1
Bulgaria............	17.5	[2] 23.1	+32	+1.2
Hungary.............	31.5	35.0	+11	+0.4
Rumania.............	17.4	24.6	+41	+1.4
Yugoslavia..........	26.7	33.3	+25	+0.9
Soviet Union........	17.0	24.8	+46	+1.6
Congo (Leopoldville)	19.6	[4] 16.8	-14	-0.5
U.A.R. (Egypt)......	39.5	32.6	-17	-0.7
South Africa........	11.5	[1] 14.9	+30	+1.1
Turkey..............	20.9	16.3	-22	-0.8
India...............	13.0	14.6	+12	+0.5
Indonesia...........	[5] 15.5	14.6	-6	-0.2
Philippines.........	9.5	9.5	0	0

[1] Major producing countries are those having 1 million acres or more of corn. Canada, having less than 1 million acres, was included to get a better economic cross section of corn-producing countries. [2] 2 years only. [3] 1955-59 data used because later data not available. [4] Average less than 5 years. [5] 1957-59 average; Ruandi-Urundi included in 1957 and 1958. [6] Java and Sumatra only.

Source: U.S. Dept. Agr. Agricultural Statistics 1949, 1962, and 1963.

Corn depletes the soil of essential nutrients much faster than many other crops. Also, being the only major grain cultivated as a row crop, it is often closely associated with soil erosion problems. As a result, those countries that continuously plant corn on the same land and lack a literate population (and therefore the technological know-how to offset this soil-depleting effect), experienced declining yields.

Five of the 6 major corn-producing countries with literacy levels below 40 percent had lower yields in 1960-62 than in 1935-39 (fig. 9). All countries with literacy levels of 50 percent or more, except the Philippines, improved yields. Gains in some of these countries, however, such as Argentina, Hungary, and Colombia, were quite modest.

Three countries other than the United States--Canada, Portugal, and France--raised corn yields 2 percent or more per year. Each of these countries, except Portugal, has had near-universal literacy for several decades. Portugal, though showing impressive percentage gains in yields during the 24 year period under survey, started from an extremely low prewar level of 12.1 bushels per acre. Yield declines, ranging from 0.5 to 1 percent per year, occurred in largely illiterate major corn-producing countries such as Turkey, Egypt, and the Congo.

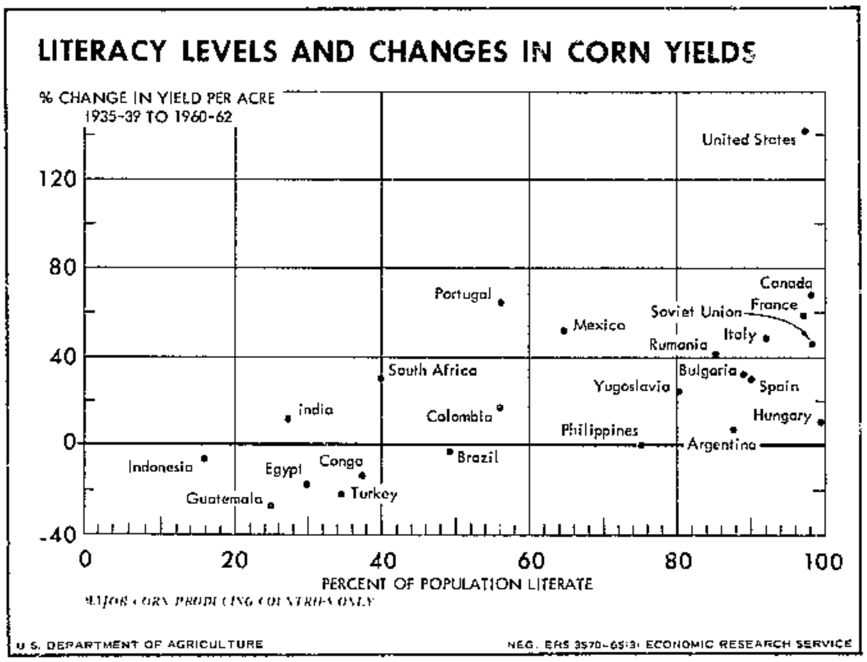

Figure 9

The Level of Per Capita Income

A certain minimal level of income per person is considered an important factor for raising yields because where incomes are still at the subsistence level there is little capital available to purchase the yield-raising inputs such as fertilizer or improved seeds. The level of income per person is also the most commonly used indicator of the level of economic development. Thus, establishing the fact that high income countries can raise yields rapidly may be to infer not only that these countries have a great deal of capital for investment in agricultfire but also that advanced countries, almost by definition, possess a much greater yield-raising capability.

Income Levels and Rice Yields

Most of the world's major rice-producing countries are characterized by very low per capita incomes. Eleven of the 13 leading rice producers have per capita incomes below $150 per year (table 11). The exceptions are Japan and the United States, where

Table 11.--Per capita income estimates, by countries, 1959[1]

Country	Annual income	Country	Annual income
	Dollars		Dollars
North America		Africa	
Canada	1,560	Algeria	230
United States	2,280	U.A.R. (Egypt)	120
		Morocco	120
Latin America		Tunisia	130
Argentina	300	South Africa	350
Brazil	170	Asia	
Chile	440	Burma	50
Colombia	200	Ceylon	120
Guatemala	150	China (Taiwan)	90
Mexico	310	India	60
		Japan	350
Western Europe		Korea (South)	100
France	1,010	Pakistan	50
Germany (West)	1,020	Philippines	150
Greece	330	Thailand	80
Italy	510	Iraq	160
Portugal	230	Turkey	140
Spain	300	Oceania	
United Kingdom	1,100	Australia	1,100

[1] Data for less-developed regions, taken from (14, p.42), are mostly for 1959. Data for developed regions, taken mostly from tables compiled by Arthur B. Mackie, Econ. Res. Serv., U. S. Dept. Agr., are either for 1959 or an average for 1959-61.

per capita incomes are $350 and $2,280 per year. Both countries have had much more success in raising rice yields than any of the low-income countries.

The low-income, rice-producing countries had uniformly modest increases in yields during the 24 years from 1935-39 to 1960-62 (fig. 10). Thailand, which experienced a decline in yields, was the only exception. Annual rates of increase in the other countries ranged from 0.3 percent per year in the Philippines to 0.9 percent in Taiwan.

Income Levels and Wheat Yields

Level of income per person and capacity to raise wheat yields are closely related. Wheat is particularly well suited for an income-per-person/yield-per-acre analysis because of the large number of major producing countries, the broad geographic distribution of these countries, and the wide range among countries in level of income per person.

Certain generalizations can be made about the relationship between income per person and the capacity to raise wheat yields. Of the 26 wheat-producing countries with 2 million acres or more

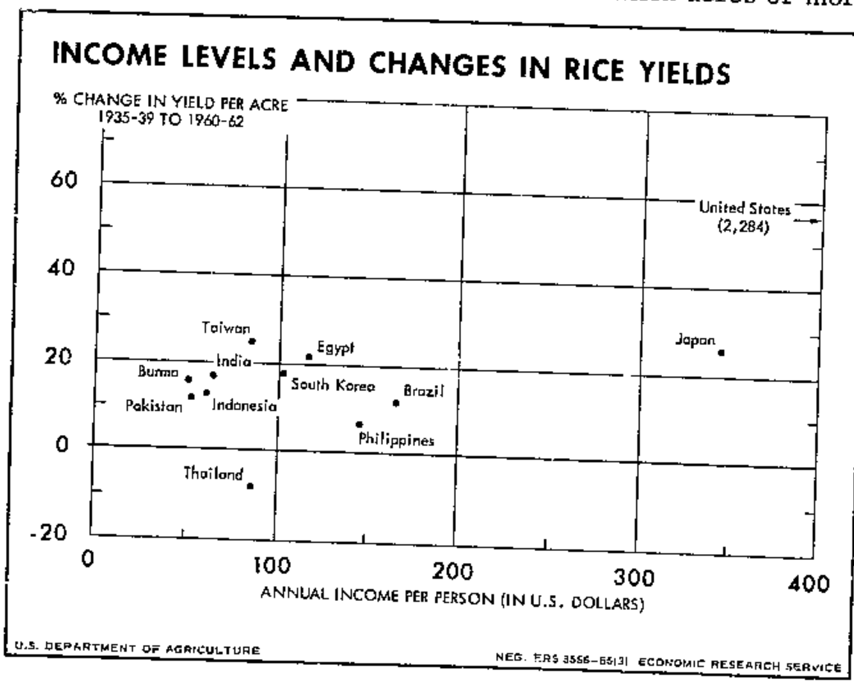

Figure 10

of wheat, 6 had per capita incomes above $1,000 per year (fig. 11). Each of these 6 countries--West Germany, France, Canada, Australia, the United Kingdom, and the United States--made impressive yield gains during 1935-39 to 1960-62. Annual compound rates of increase ranged from 1.5 percent in Germany and Australia to 2.7 percent in the United States.

At the other end of the income range, 7 countries had annual per capita incomes below $200. Within this group, 2 countries--Brazil and Tunisia--experienced declining yields; Morocco increased yields 1.3 percent per year; yield increases in the other countries in this group ranged from less than 0.1 percent per year in Iraq to 0.6 percent per year in India.

All other major wheat-growing countries are in the $200 to $1,000 middle-income group. Increases in yields in this group were in general very modest. Performance in this group was little different than in the low-income group, except for 3 things. First, no middle-income countries experienced declining yields, although one country, the Soviet Union, was not able to increase wheat yields at all. Second, 2 of the 15 countries in this group, Mexico and Greece, did raise yields quite rapidly. Third, the annual yield gains in this group of countries tended to be somewhat greater than in the low-income group, being concentrated

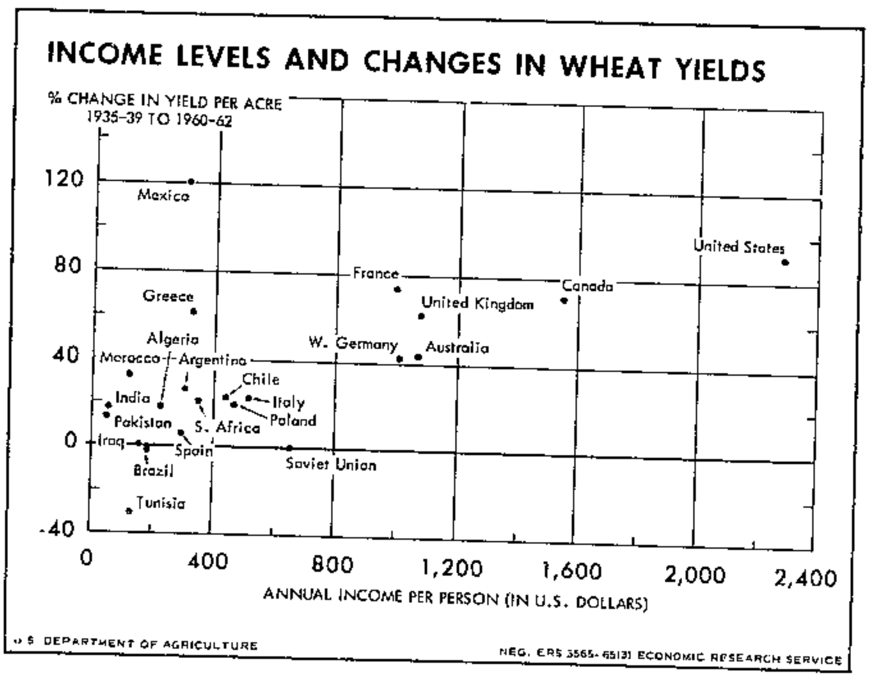

Figure 11

between 0.5 and 1 percent per year, compared with 0.5 percent per year and less.

Income Levels and Corn Yields

The capacity to increase corn yields, as with rice and wheat, is closely related to the level of income per person. Only 3 major corn-producing countries (France, Canada, and the United States) had per capita incomes above $1,000 per year. All 3 made dramatic gains in corn output per acre, ranging from 2 percent annually in France to 3.7 percent in the United States (fig. 12). If the phenomenally high U.S. rate of increase in corn yields prevailing during the past 24 years continues, corn yields will quadruple prewar yields by 1975.

Ten major corn-producing countries were in the middle-income group, with incomes ranging from $200 to $1,000. All these countries raised corn yields between 1935-39 and 1960-62, except Turkey, where yields declined 21 percent, or 0.8 percent per year. Annual rates of increase ranged from a modest 0.3 percent per year in Argentina to 2.1 percent in Portugal. Eight important corn-producing countries had per capita incomes below $200 per year.

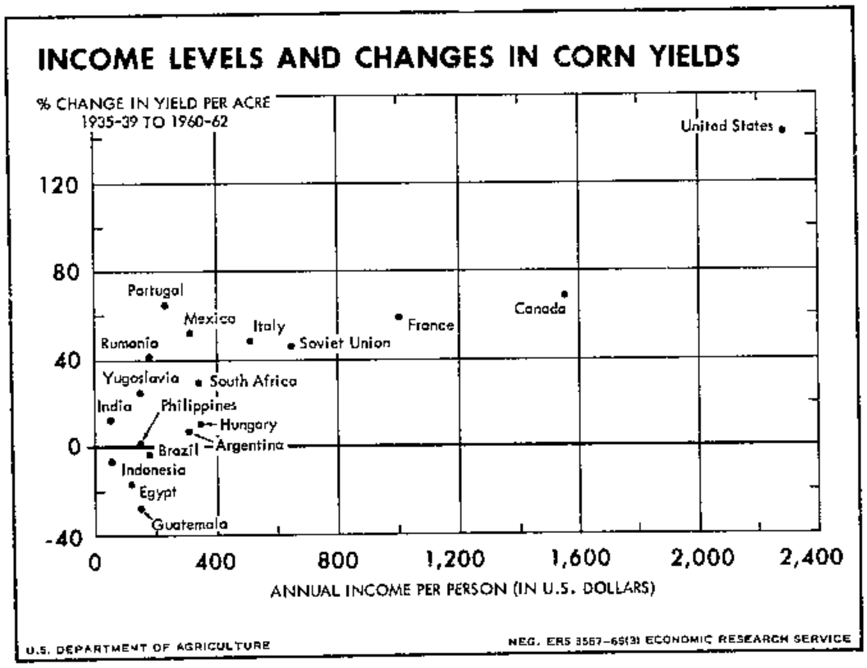

Figure 12

In 5 of these countries, corn yields declined. In Egypt, Turkey, and Guatemala, the annual rate of decline approached 1 percent per year. India and Bulgaria were the only low-income countries able to raise corn yields.

In summary, high-income, corn-producing countries achieved impressive gains in yields; nearly all middle-income countries raised yields but at comparatively modest rates; most low-income countries were unable to raise yields and, in fact, most experienced actual declines in yields--some of a very substantial magnitude.

Market Orientation of Agriculture

Market orientation refers to the share of farm output marketed. It thus indicates how far an economy has progressed from being a traditional, subsistence-oriented economy toward becoming a commercial, market-oriented economy. The more commercial and market-oriented the agricultural sector becomes, the easier it is, other things being equal, to finance the capital inputs required to raise yields. When food output is increased by the conventional means of expanding the area under cultivation, the capital inputs required are minimal. But when food output can be increased only by raising yields, increased capital inputs are necessary.

The proportion of agricultural output marketed is influenced by many things such as the types of crops, prices of farm products, availability of marketing information, and proximity to markets. Larger farms are usually more market-oriented and smaller farms more subsistence-oriented.

Data on the share of farm output marketed is available for only a few countries. Approximations of the share of farm output marketed can be made by means of a variety of estimating techniques. The value of agricultural commodities exported, allowing for the difference between farm prices and export prices, expressed as a share of farm output, gives a minimal figure. This can then be adjusted by taking into account the share of population not living on farms. Further refinements can be made by examining individual crops: industrial crops, such as rubber and sisal, for instance, may be entirely marketed, because there is no opportunity for on-farm consumption. Special knowledge of localization of output of certain commodities may also aid in estimating the shares of farm output marketed.

When output per farm family is low and the share of output marketed is small, there are many competing demands on the limited amount of cash available. Family necessities often take priority, leaving little for investment in capital inputs.

Table 12.--United States: Share of farm output consumed in farm households, 1910-62,

Period	Share consumed on farm[1]
	Percent
1910-15....................	16.7
1916-20....................	15.7
1921-25....................	15.6
1926-30....................	14.1
1931-35....................	15.6
1936-40....................	12.7
1941-45....................	10.0
1946-50....................	8.5
1951-55....................	6.4
1956-60....................	4.5
1961-62....................	3.0

[1] Calculated by dividing value of home consumption by combined value of cash receipts from farming plus value of home consumption.

Source: U.S. Dept. Agr. Farm Income Situation, July 1963.

The share of farm output marketed in the United States, one of the few countries for which data are available, is quite high (table 12). During the 1910-15 period, 83 percent of U.S. farm output was marketed. By 1962 it had reached 97 percent.

At the time of the yield takeoff in the United States (beginning about 1940), the share of farm output marketed was around 90 percent. Data are not available for Australia and the United Kingdom, both experiencing a yield takeoff at about the same time; but it would not seem unreasonable to assume that the share of output marketed was also quite high, possibly about the same as in the United States.

The share of farm output marketed in many less-developed countries today is much less than half and in some, where levels of agricultural productivity are particularly low, it may be less than one-fourth. In these countries, capital for investment in agriculture is quite scarce. The raising of yields, so dependent on increased capital inputs, will be a slow and arduous process.

The Nonagricultural Supporting Sector

The nonagricultural supporting sector is here defined as that part of the economy outside the agricultural sector which provides either goods or services in support of the agricultural sector. In a traditional society where food output is increased simply by expanding the area under cultivation, agriculture can function rather independently of the remainder of the economy. But once the supply of cultivable land is exhausted and food output can be increased only by raising yields, the relationship changes. Agriculture becomes quite dependent on the remainder of the economy for the goods and services required to raise yields.

A modern, yield-raising agriculture is dependent upon the remainder of the economy for a wide variety of goods and services. Goods include all the physical inputs such as fertilizer, lime, insecticides, fungicides, herbicides, tractors, farm implements, tools, petroleum products, and many more. Services include such things as transportation, financing, communications, research, and marketing.

Goods and services must be considered together. A development plan which provides for the production of a given amount of fertilizer must, if it is to be successful, also provide farm credit, and storage, transport, and distribution facilities. Not only must the fertilizer be produced; it must also be made available to farmers at the proper time. And further allowance must be made for agricultural research and extension programs which will tell the farmer how and when to apply the fertilizer, under conditions which often vary widely within a country.

A less-developed economy, faced with the necessity of raising yields, can, if it has sufficient foreign exchange, import some of the goods required, such as fertilizer. Most services, however, must be produced indigenously. Thus, the development of a yield-raising capability is dependent directly or indirectly on indigenous resources.

Perhaps the best general indicator of the level of development of the nonagricultural supporting sector is the share of the national product accounted for by the economy outside agriculture (fig. 13). The greater this share is, the more likely it is that an economy will be able to support a yield takeoff. Japan's takeoff occurred at a time when the nonagricultural portion of the economy was accounting for just under 60 percent of the national product. In both the United States and the United Kingdom, the figure was 90 percent or above at the time of takeoff. In India, the nonagricultural sector today accounts for scarcely 50 percent of the national product--substantially less than in any of the posttakeoff countries mentioned above (tables 13-16).

Once an economy reaches the point where an adequate food supply is contingent upon raising yields, the agricultural and nonagricultural sectors must develop together. Neither sector is likely

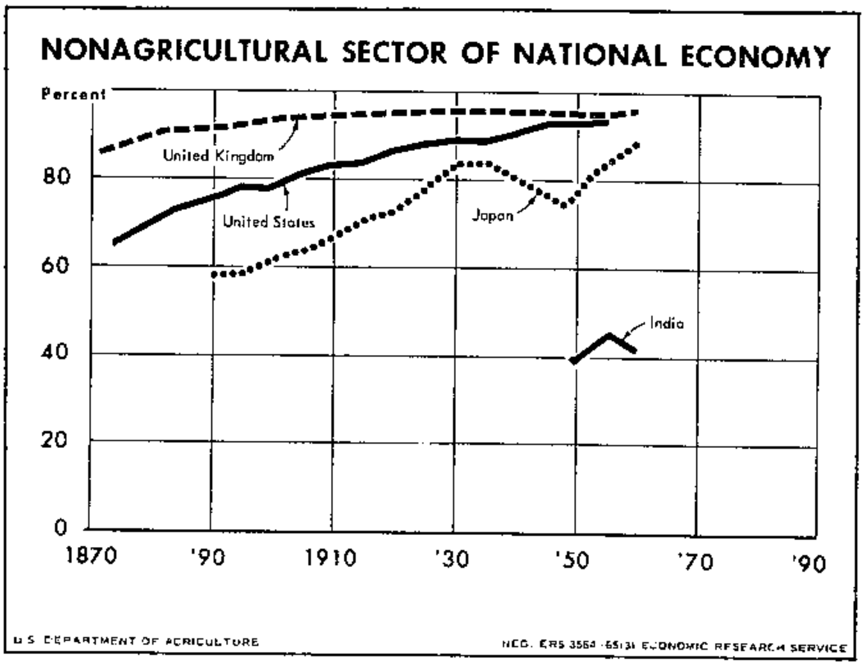

Figure 13

to go far if the other remains static. Industrial development should be coordinated with agriculture's needs. This requires that planners be aware of the intersectoral implications of the shift from an area-expanding agriculture to a yield-raising agriculture.

Agricultural research related to farm production inputs is one of the most important services provided to agriculture by industry in an advanced economy. In the early stages of development, nearly all agricultural research must be undertaken by government, since individual farmers lack the technical and financial resources required to do sophisticated research. As an economy develops, however, private corporations, depending upon the farmer as a market, or looking to him as a supplier of foodstuffs and raw materials, often assume a growing share of the agricultural research load, particularly in specialized areas of interest.

In the United States, the investment by industry in agricultural research now exceeds that of government, both Federal and State. Not only do the major industrial corporations associated with agriculture have extensive research programs, but they also employ large numbers of fieldmen responsible for getting the results of research on their products to farmers. These fieldmen, who usually assist farmers with specialized problems, include agronomists,

Table 13.--Japan: Relative importance of agricultural and nonagricultural sectors in the economy, 1888-1960

Year or period	Agricultural sector[1]	Nonagricultural sector	Total
	Percent	Percent	Percent
1888-1892	42.4	57.6	100
1893-1897	41.5	58.5	100
1898-1902	37.7	62.3	100
1903-1907	36.3	63.7	100
1908-1912	33.3	66.7	100
1913-1917	28.6	71.4	100
1918-1922	26.7	73.3	100
1923-1927	21.8	78.2	100
1928-1932	16.5	83.5	100
1934-1936	16.6	83.4	100
1948	25.7	74.3	100
1952	18.8	81.2	100
1956	14.4	85.6	100
1960	10.8	89.2	100

[1] Based on real net output by industrial sectors, calculated in terms of 1928-32 prices for data through 1932 and current prices thereafter. Prior to 1932, original data were for primary industry, which included forestry and fishing in addition to agriculture. Data for recent decades and occasional references for earlier years indicate that the agricultural share of primary industry is about 80 percent. This figure was used to reduce the primary industry share to agriculture only for the period 1888 to 1932.

Source: (69)

entomologists, plant pathologists, agricultural engineers, and many others.

Most of the backlog of agricultural technology existing in the world today is temperate zone technology--developed in countries in temperate zones for temperate zone products. Most basic principles and practices now used in the economically advanced, temperate zone countries can be transferred to the less-advanced countries situated largely in the tropical and subtropical regions. But much adaptive research will be required to modify the results of temperate zone research for tropical use. Adaptive research programs on the scale needed will require many more researchers

Table 14.--United Kingdom: Relative importance of agricultural and nonagricultural sectors in the economy, 1801-1960

Year or period	Agricultural sector[1]	Nonagricultural sector	Total
	Percent	Percent	Percent
1801.......	32.5	67.5	100
1811.......	35.7	64.3	100
1821.......	26.1	73.9	100
1831.......	23.4	76.6	100
1841.......	22.1	77.9	100
1951.......	20.4	79.6	100
1861.......	17.8	82.2	100
1871.......	14.2	85.8	100
1881.......	10.4	89.6	100
1891.......	8.6	91.4	100
1901.......	6.4	93.6	100
1924.......	4.1	95.9	100
1935.......	3.9	96.1	100
1955.......	4.7	95.3	100
1960.......	[2] 4.1	95.9	100

[1] Calculated on basis of industrial distribution of national income; includes forestry and fishing; data from 1801 to 1924 pertain to Great Britain only.
[2] Agricultural share of the gross domestic product.

Source: (66).

than can be trained within the less-developed regions in the foreseeable future. This shortage of research talent within the developing countries can be overcome only by importing large numbers of agricultural scientists from the now-advanced countries. These scientists can serve a dual function by organizing local research programs and by training local counterparts in the requisite research skills.

A country lacking a well developed, nonagricultural supporting sector would likely find it extremely difficult, if not impossible,

Table 15.--United States: Relative importance of agricultural and nonagricultural sectors in the economy, 1869-1960

Year or period	Agricultural sector[1]	Nonagricultural sector	Total
	Percent	Percent	Percent
1869-1878...	35.3	64.7	100
1879-1888...	27.3	72.7	100
1889-1893...	24.0	76.0	100
1892-1896...	22.3	77.7	100
1897-1901...	22.5	77.5	100
1902-1906...	19.0	81.0	100
1907-1911...	16.7	83.3	100
1912-1916...	16.2	83.8	100
1917-1921...	13.5	86.5	100
1925........	11.6	88.4	100
1930........	10.6	89.4	100
1935........	11.4	88.6	100
1940........	9.5	90.5	100
1945........	6.8	93.2	100
1950........	6.9	93.1	100
1955........	6.2	93.8	100

[1] Farm share of gross domestic product in 1929 dollars.

Source: (18)

to generate a yield takeoff. It should be noted that the failure of both the United States and the United Kingdom to raise yields during World War I, when food was in short supply and prices of farm products were very favorable, may have been due in part to the lack of a well developed nonagricultural supporting sector. Two and a half decades later, when a similar situation developed, both economies responded with dramatic increases in yields.[2]

[2] Another factor probably contributing to the lack of response on the part of the farmers was the lack of forward price assurance.

Table 16.--India: Relative importance of agricultural and nonagricultural sectors in the economy, 1949-60

Year or period[1]	Agricultural sector[2]	Nonagricultural sector	Total
	Percent	Percent	Percent
1949.......	49.8	50.2	100
1950.......	51.3	48.7	100
1951.......	50.4	49.6	100
1952.......	49.0	51.0	100
1953.......	50.7	49.3	100
1954.......	45.3	54.7	100
1955.......	45.3	54.7	100
1956.......	48.8	51.2	100
1957.......	46.4	53.6	100
1958.......	49.5	50.5	100
1959.......	48.0	52.0	100
1960.......	48.3	51.7	100

[1] Fiscal years are presented as calendar years, i.e., 1949 = Indian fiscal year 1949-50.
[2] Calculated on basis of industrial distribution of national income.

Source: (49).

Summary

It is evident at this point that desire on the part of economic planners to increase food output by raising yields is not in itself sufficient. The means to raise yields must be available. As outlined in this chapter, these include a rather high level of literacy in the farm population, the availability of capital to purchase yield-raising inputs, and the ability of the nonagricultural sector to provide both the goods and the services needed to raise yields. These are not the only factors that may be needed for a yield takeoff, but they represent some of the most important ones.

Among those countries ranking as major producers of at least 1 of the 3 leading grains, none of the low-literacy countries (less than half the population literate) made any pronounced progress in raising yields during 1935-39 to 1960-62. None achieved a rate of increase in yields higher than 1 percent per year, except the Republic of South Africa, which raised corn yields at the rate of

1.1 percent per year over the 24-year period. In several low-literacy countries, especially those ranking as major corn producers, yields actually declined. The average rate of yield increase for this group of countries was only 0.17 percent per year.

Progress in raising yields was mixed among the more literate countries. Among 13 countries with literacy levels between 50 and 80 percent, 11 had rising yields, 1 had declining yields and in 1, yields were exactly the same in 1960-62 as in 1935-39. This group of countries raised yields an average of 1.12 percent per year.

Some 23 major grain-producing countries had literacy levels above 80 percent. Twenty-two of these countries increased yields during the 24-year period; in 1 country yields were unchanged. Yields increased an average of 1.43 percent per year in this group. Those countries having near-universal literacy for several decades performed much better than those only recently reaching this level.

The available evidence indicates that it is exceedingly difficult for largely illiterate societies to develop a significant yield-raising capability. A high level of literacy, however, does not ensure a yield takeoff.

The relationship between the level of per capita income and the capacity to raise yields is revealing. Some 24 countries ranking as major producers of rice, wheat, or corn have average per capita incomes below $200 per year. Per acre yields increased in 14 of these countries between 1935-39 and 1960-62; in 8 countries they declined, and in 2 countries they remained the same. Yields in this group increased an average of 0.18 percent per year or about 1 percent every 5 years.

Twenty-five major grain-producing countries had average per capita incomes between $200 and $1,000 per year. Yields trended upward in 24 of these countries; in 1 they were unchanged. This group of middle-income countries raised yields at a rate of 1.03 percent per year.

Ten major grain-producing countries had per capita incomes above $1,000 per year. Every one of these countries achieved dramatic increases in yields per acre. The lowest rate of increase recorded by this group was 1.5 percent per year, and the highest, 3.7 percent per year. The average rate of gain was 2.21 percent.

Determining the importance of the share of output marketed as a factor in a yield takeoff is difficult because of the lack of data for most countries. It is evident, however, that in traditional, subsistence oriented economies, little cash is available for investment in yield-raising capital inputs. Some 90 percent of farm output was being marketed in the United States at the time of the yield takeoff. The share of farm output marketed in the other case-study countries attaining a yield takeoff in recent years--Australia and the United Kingdom--was also quite high. In India, the only one of the case-study countries that has not yet generated a yield takeoff, the share of output marketed is quite low, possibly well below one half.

So long as food output can be expanded simply by expanding the area under cultivation, the agricultural sector can remain rather independent of the remainder of the economy. But to raise yields, agriculture depends on the nonagricultural sector for yield-raising inputs. If the nonagricultural sector is not sufficiently developed to provide the goods and services needed, then a yield takeoff may be very difficult, if not impossible.

The lack of any 1 of these 4 facilitating factors would probably prevent a yield takeoff. The level of income per person is perhaps the best single general indicator of yield-raising capability. Stated otherwise, the capacity to raise yields is closely related to the level of economic development (fig. 14). North America, the most advanced region, increased grain yields at a compound annual rate

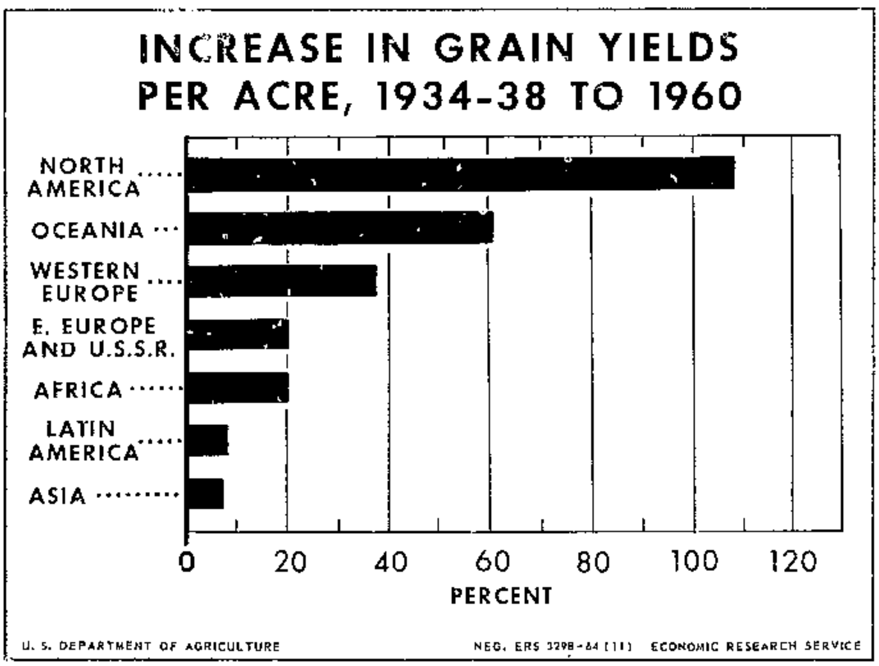

Figure 14

of 3.1 percent from 1934-38 to 1960 (table 17).[3] Oceania (Australia and New Zealand) and Western Europe, ranking second and third in level of income per person, increased grain yields during the same period at the rate of 2.1 and 1.3 percent per year. The less-developed world, consisting of Asia, Africa, and Latin America, raised yields at an average rate of 0.3 percent per year.

[3] Yields in North America were below average during the 1934-38 period because of unfavorable weather. Had weather conditions in 1934-38 been more nearly normal, the rate of increase to 1960 would have been slightly below 3 percent per year.

Table 17.--Trends in grain yield per acre by geographic and economic regions, 1934-38 to 1960

Geographic and economic regions	Grain output per harvested acre		Increase 1934-38 to 1960	Annual compound rate of increase 1934-38 to 1960
	1934-38	1960		
	Kilograms		Percent	Percent
Geographic regions:				
North America	443	927	109	3.1
Latin America	461	498	8	.3
Western Europe	638	876	37	1.3
Eastern Europe & USSR	429	514	20	.8
Africa	265	318	20	.8
Asia	508	542	7	.3
Oceania	331	535	62	2.1
Economic regions[1]				
Developed regions	462	699	51	1.7
Less-developed regions	468	506	8	.3

[1] Less-developed regions are Asia, Africa, and Latin America; the remaining 4 regions are classified as developed.

Source: (14), table 21.

Chapter VI.--PRETAKEOFF FACTORS: NECESSARY BUT NOT SUFFICIENT

Although the factors described in the preceding chapter may be necessary for a yield takeoff, they are not sufficient. In addition, certain incentives are also required.

Among these incentives are favorable prices for farm products, but such prices are not enough. The people on the land must be the principal beneficiaries of favorable prices. There must be a strong link between effort and reward. The nature of this link is determined by such things as land tenure systems and tax systems.

Incentives differ from the pretakeoff factors discussed in the previous chapter in that they can often be developed quickly by direct government action. A program to maintain favorable prices for farm products, a land reform program, or a tax reform program must be undertaken by government. Given enlightened leadership and otherwise generally favorable circumstances, these incentives can be developed quickly. But developing the factors needed for a yield takeoff such as raising incomes high enough above the subsistence level to enable farmers to purchase the necessary yield-raising inputs may require several years or possibly even decades.

Some Necessary Incentives for Raising Yields

Favorable Prices

The term "favorable prices" for farm products may be variously defined. It may mean favorable with respect to past price levels, favorable compared with prices of like products in other countries, or it may mean favorable when compared with certain things the farmer must buy. In this discussion, favorable prices will mean favorable in relation to those purchased inputs required to raise yields. And prices for farm products refers to prices at the farm level--i.e., prices received by the farmer.

Improvements in prices may not have much effect on yields or output in a traditional, subsistence-oriented economy. Levels of productivity are low and farmers produce food staples largely for their own needs, considering the market as an outlet for excess output in good crop years. Stated otherwise, subsistence farmers do not plan as carefully or as consciously for the market as do farmers in a market-oriented economy.

When considering the use of a given input, farmers must estimate additional output expected as a result of its use. The value of additional output must be related to the cost of each input to determine profitability. Longer term investments in land improvements are influenced by the longer term price outlook. Uncertain long-term price prospects discourage long-term investments in such yield-raising inputs as irrigation or drainage systems. Nearly all advanced Western countries now have some kind of price support for principal agricultural commodities.

The failure of grain yields in both the United Kingdom and the United States to respond to the favorable prices prevailing during World War I may be at least partly attributable to the fact that farmers did not expect the favorable wartime prices to continue and were therefore not interested in experimenting with new yield-raising inputs or cultural practices (table 18, figs. 15-17). This contrasts with the situation going into World War II when governments of both the United States and the United Kingdom already had long-term policies of supporting prices of farm products adopted during the 1930's.

Table 19.--United States and the United Kingdom: Prices of selected grains, 1900-1962

Year	United States		United Kingdom	Year	United States		United Kingdom
	Wheat per bushel[1]	Corn per bushel[1]	Wheat per cwt.		Wheat per bushel[1]	Corn per bushel[1]	Wheat per cwt.
	Dollars	Dollars	Shillings[2]		Dollars	Dollars	Shillings[2]
1900.....	0.62	0.35	[illegible]	1932.....	0.38	0.32	5.92
1901.....	.63	.60	5.57	1933.....	.74	.52	5.33
1902.....	.63	.40	5.85	1934.....	.85	.82	4.83
1903.....	.69	.42	5.97	1935.....	.83	.66	[2] 8.83
1904.....	.93	.44	5.90	1936.....	1.02	1.04	9.42
1905.....	.75	.41	6.18	1937.....	.96	.52	9.92
1906.....	.66	.39	5.88	1938.....	.56	.49	9.75
1907.....	.87	.50	6.37	1939.....	.69	.57	10.17
1908.....	.97	.65	6.67	1940.....	.68	.62	12.42
1909.....	.94	.62	7.69	1941.....	.94	.75	14.50
1910.....	.91	.52	6.60	1942.....	1.10	.92	15.92
1911.....	.87	.68	6.60	1943.....	1.36	1.12	17.67
1912.....	.81	.55	8.08	1944.....	1.41	1.03	18.92
1913.....	.79	.70	7.42	1945.....	1.49	1.23	19.67
1914.....	.97	.71	8.17	1946.....	1.90	1.53	18.58
1915.....	.96	.68	12.33	1947.....	2.29	2.16	19.75
1916.....	1.43	1.13	13.58	1948.....	1.98	1.28	23.67
1917.....	2.05	1.45	17.67	1949.....	1.88	1.24	24.33
1918.....	2.05	1.52	27.00	1950.....	2.00	1.52	26.58
1919.....	2.16	1.51	17.00	1951.....	2.11	1.66	28.08
1920.....	1.83	.64	18.83	1952.....	2.09	1.63	25.75
1921.....	1.03	.52	16.67	1953.....	2.04	1.48	30.42
1922.....	.97	.73	11.17	1954.....	2.12	1.43	31.08
1923.....	.93	.81	9.83	1955.....	1.98	1.35	31.00
1924.....	1.25	1.06	11.50	1956.....	1.97	1.29	30.25
1925.....	1.44	.79	12.17	1957.....	1.93	1.11	29.08
1926.....	1.22	.74	12.42	1958.....	1.75	1.12	28.25
1927.....	1.19	.85	11.50	1959.....	1.76	1.04	27.25
1928.....	1.00	.84	10.00	1960.....	1.74	1.00	26.92
1929.....	1.04	.80	9.83	1961.....	1.83	1.08	26.75
1930.....	.67	.60	8.00	1962.....	2.02	1.08	27.34
1931.....	.39	.32	5.75				

[1] Season-average price per bushel received by farmers; includes subsidies of various kinds.
[2] Prices after 1934 appear to include payments made to farmers under various schemes.

Source: (66, 35, 92).

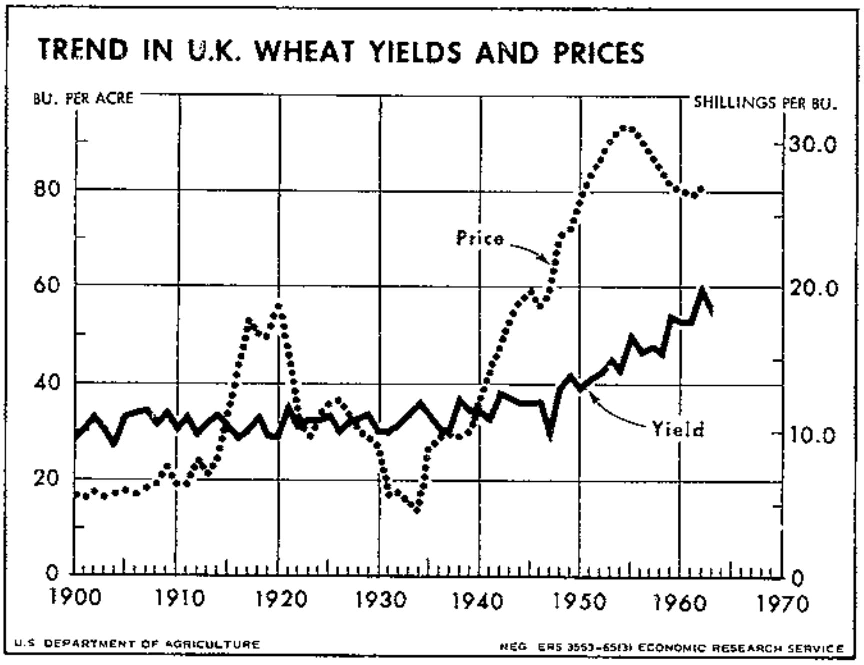

Figure 15

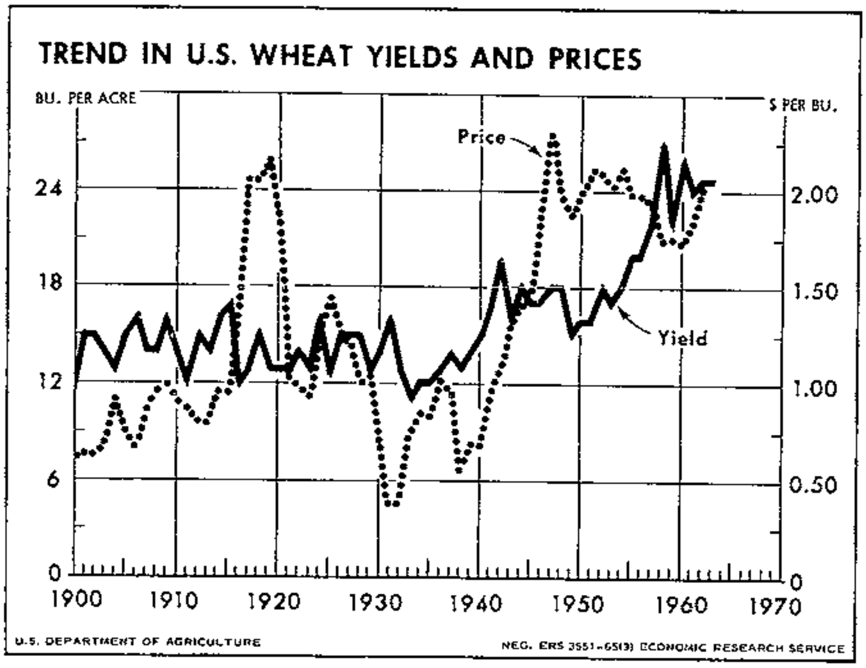

Figure 16

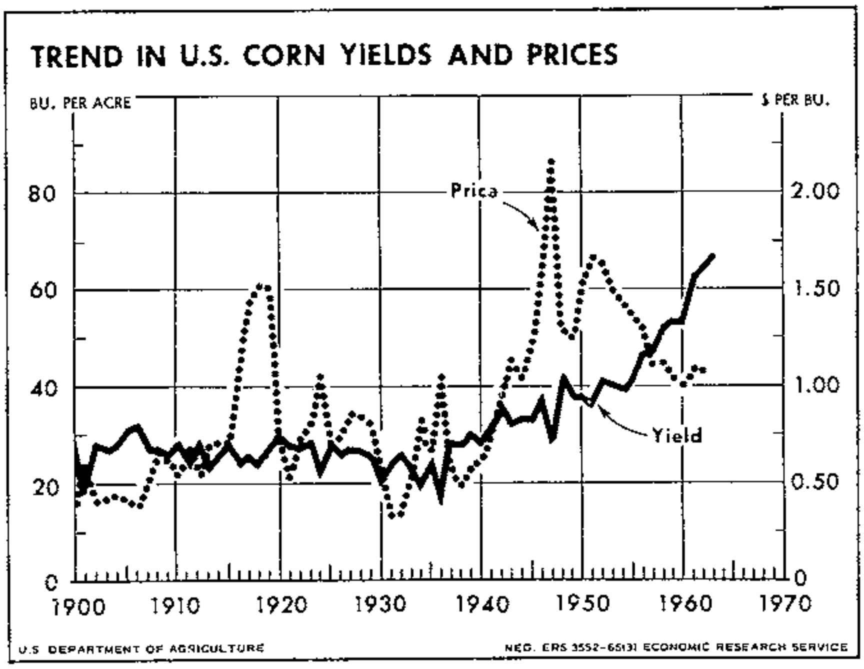

Figure 17

In less-developed countries where many yield-raising inputs, especially agricultural chemicals such as fertilizer and pesticides, must be imported, the cost is often higher than in developed countries. Thus, prices of farm products often must be higher than in developed countries--if steadily rising yields are to become a reality.

Favorable prices for grains had a key role in the grain yield takeoffs occurring in the case-study countries discussed in Chapter IV. Improvements in rice prices in Japan beginning shortly after the Meiji restoration of 1868 undoubtedly contributed to the yield takeoff in the latter part of the 19th century.

Some form of support prices for major grains was adopted during the depression decade of the 1930's by the United Kingdom, United States, and Australia. These support prices did much to stabilize farm prices and improve the long-term outlook. Farmers, assured of reasonable prices, were willing to invest more in production capital, both short-term and long-term.

Once the yield takeoff has occurred and farmers become conditioned to a constantly changing technology, price levels may not greatly influence the yield trend. Changes in price could conceivably reduce the rate of increase in yields, but it does not seem likely that they would arrest or reverse the trend except under the most adverse circumstances.

Linking Effort and Reward

In many less-developed countries, landownership is concentrated in the hands of a small number of people. A substantial part of any improvement in the prices of farm products thus accrues to the landowners, not to the person working the land. Land reform can often remedy this problem.

Tax systems, too, can mitigate the effect of any improvement in farm prices. Some less-developed countries collect a large part of their revenue by means of an export tax on an agricultural commodity or commodities. This has the effect of depressing the prices of farm products in relation to the costs of yield-raising capital inputs.

A third institutional factor, often weakening the link between effort and reward in agriculture, is the system of state and collective farms common to so many of the Communist Bloc countries. This is undoubtedly the single most important factor responsible for the poor performance of agriculture in the Bloc countries.

Once the necessary actions are taken to correct the situations mentioned above so that the farmer does in fact receive the additional income associated with improving prices for his products, still another step remains. Farm families must have access to consumer goods that can improve their lot. Unless the additional income can be used to purchase these goods, the extra money will have little meaning or value.

Pretakeoff Factors Plus Incentives: The Essential Combination

It is not surprising that yield takeoffs are such recent phenomena, since they require a combination of many pretakeoff factors and incentives occurring or existing simultaneously. Both the United States and the United Kingdom apparently had all the necessary incentives, including extremely favorable prices for farm products during World War I, but neither attained a yield takeoff.

Given the apparent existence of incentives in these countries, the failure to attain a yield takeoff may be at least partly attributable to a lack of some of the factors needed for a yield takeoff. Two and a half decades later, during World War II, grain prices again rose sharply, at least doubling those of the interwar years. This time, yields responded immediately and dramatically, initiating yield takeoffs in both countries.

Apparently, the factors for a yield takeoff, not present earlier, now existed in both countries. The price support programs adopted by both countries during the mid-1930's, with their inherent element of forward price assurance, may also have amplified the response of farmers to the favorable prices. Possibly, the conditions existing at the time of World War I would have been sufficient to generate a yield takeoff--if the high grain prices had prevailed for a longer period of time or farmers could have been assured that prices would not drop to disastrously low levels after the war.

At one time or another, many countries have had, for one reason or another, favorable prices for farm products. Many have successfully executed land reform programs, thus ensuring that those working the land benefit from favorable prices. Others have attained near-universal literacy. Some countries have made much progress in developing the nonagricultural supporting sector discussed in the preceding chapter. But relatively few countries, and most of these only quite recently, have possessed at any given time all the factors and incentives required to generate a yield takeoff.

Chapter VII.--THE UNITED STATES AND JAPAN: CONTRASTING PATHS OF AGRICULTURAL DEVELOPMENT

The United States and Japan have followed very different paths of agricultural development. The United States, throughout most of its history, has emphasized output per person in agriculture. Japan has concentrated its efforts in expanding output per acre. Each country followed the path of development best suited to its particular circumstances and needs. This chapter examines the consequences of the contrasting approaches, the underlying reasons, and the implications for today's less-developed countries.

Long-term historical data on the productivity of agricultural labor and agricultural land, using the same definitions and time periods for both economies, are not available. Data are available, however, for the principal crops produced in each country--rice in Japan and corn in the United States--from 1900 to 1960 (table 19). Although trends in agricultural labor productivity for 1 crop are not necessarily the same as those for the entire agricultural sector, they are nonetheless useful indicators, especially when the 2 crops

Table 19.--Indicators of land and labor productivity trends in U.S. and Japanese agriculture, 1900-1960[1]

Indicator	1900	1920	1940	1950	1960[2]
Land productivity:					
U.S.: corn produced per acre (bushels)	25.9	28.4	30.3	39.0	61.7
Japan: rice produced per acre (kilograms)	766	1,059	1,214	1,189	1,435
U.S.: corn produced per acre (index)[3]	100	110	117	151	238
Japan: rice produced per acre (index)[3]	100	138	158	155	187
Labor productivity:					
U.S.: corn produced per 100 man-hours (bushels)	68.0	88.5	120.5	256.4	909.1
Japan: rice produced per 100 man-hours (kilograms)[4]	946	1,123	1,493	1,436	2,067
U.S.: corn produced per 100 man-hours (index)[3]	100	130	177	377	1,337
Japan: rice produced per 100 man-hours (index)[3]	100	119	158	152	218

[1] Corn, the leading U.S. crop, exceeds the combined output of all other U.S. grains. Rice, Japan's leading crop, is grown on 4/5 of all farms, occupies 2/5 of the plan ed area, and accounts for 1/2 of all crop production. [2] U.S. data are for 1960-63. [3] 1900 = 100. [4] 1899 data used for 1900; 1922 data used for 1920; and 1939 data for 1940.

Source: U.S. data from U.S. Dept. Agr.; Japanese data from Ogura (69), and appendix tables.

loom so large in their respective agricultural economies. Corn accounts for well over half of all grain produced in the United States, and rice accounts for three-fourths of Japan's total grain production.

Increases in yields of rice in Japan and corn in the United States during 1900 to 1960 have been of approximately the same magnitude (fig. 18). Japan's yield gains were rather evenly distributed

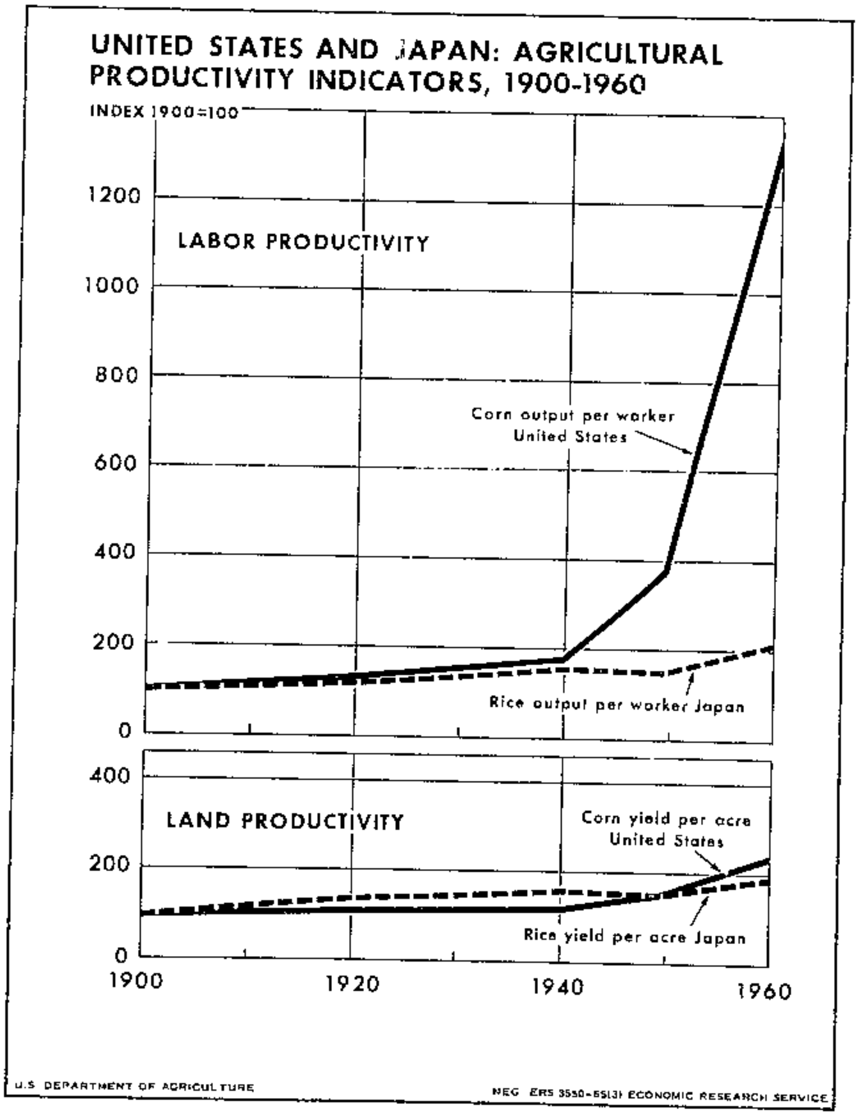

Figure 18

over the entire period, whereas those of the United States were concentrated in the last 2 decades.

Japan's rice yields, averaging 766 kilograms per acre in 1900, reached 1,059 kilograms in 1920, 1,214 kilograms in 1940, and 1,435 kilograms in 1960. Gains for each 20-year period were 293, 155, and 221 kilograms, respectively. Corn output per acre in the United States, at 25.9 bushels in 1900, was still only 30.3 bushels in 1940. However, during the next 20 years, yields more than doubled, to 61.7 bushels in 1960. Increases in Japanese rice yields and U.S. corn yields over the 60-year span were 87 and 138 percent, respectively.

Although trends in agricultural land productivity in both countries are quite similar, trends in agricultural labor productivity diverge sharply. The trend in agricultural labor productivity in Japan closely parallels that of agricultural land. Between 1900 and 1960, output of rice per acre increased 87 percent and output per man-hour increased 118 percent. This close relationship between land and labor productivity is not surprising--it is characteristic of a fixed-land economy, in which the farm population has not yet begun to decline appreciably.[1]

The productivity of agricultural labor in the United States increased dramatically between 1900 and 1960, especially after 1940. Corn output per man-hour climbed from 68 bushels per 100 man-hours in 1900 to 909 bushels in 1960--an increase of 13-fold!

In 1900, the average Japanese farmer produced 946 kilograms of rice per 100 man-hours invested in the production of rice. For the American corn grower, the comparable figure was just over 1,730 kilograms, less than twice as much. But the value of a kilogram of corn is much less than the value of a kilogram of rice. Thus, the productivity of agricultural labor used in the production of the 2 major grains, at least, was not too different in the 2 economies as of 1900. But by 1960, the productivity of agricultural labor in the United States was several times higher.

In terms of human welfare, output per person in agriculture is the relevant indicator. Output per acre has implications for human welfare only insofar as it affects output per person. There does not seem to be any practical way for Japan, with its very dense population, to overcome the vast difference in output per person in agriculture unless it can attain a level of development far more advanced than that in the United States.

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[1] Gains in labor productivity in an essentially fixed-land economy can appreciably exceed those in land productivity only insofar as the agricultural population is reduced, and this does not usually occur in the early stages of development.

Both the United States and Japan have made exceptional efforts to develop their agricultural sectors, their agricultural technologies are among the most advanced in the world. The current vast difference in output per person in agriculture is not due to any lack of effort on the part of the Japanese. It traces largely to the fact that Japan exhausted its supply of cultivable land quite early in its development; Japan had become a fixed-land economy before it had scarcely begun to industrialize. The United States was fortunate enough to reach a rather advanced stage of development before it ceased expanding the area under cultivation.

Why the Different Paths?

Japan was essentially a fixed-land agricultural economy by the latter part of the 19th century. Opportunities for expanding the food-producing area were limited. The grain acreage harvested in 1900-02, averaging 11.4 million acres, has remained essentially unchanged, averaging 11.5 million acres in 1960-62.

Given the fixed-land situation and continuing growth of population, the alternatives were limited. Japan could generate a yield takeoff, become increasingly dependent on food imports, or accept a declining trend in per capita food consumption.[2] The latter 2 alternatives, resulting in either a drain on the limited supply of foreign exchange or a decline in food consumption levels and an eventual increase in malnutrition, would not have been conducive to Japan's economic development. These alternatives might in fact have precluded the possibility of an income per person takeoff: Stated otherwise, Japan might have been caught in the low-income trap.[3]

Fortunately, Japan chose to generate a yield takeoff. This policy, in force from shortly after the Meiji restoration in 1868, was supported by government at national, provincial, and local levels. The yield takeoff was in evidence as early as 1880 and was a certainty by the end of the century.

During the latter part of the 19th century, when Japan was generating a yield takeoff, the United States was still pushing its frontier westward. It was not until just before World War I that settlement of the frontier ended.

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[2] A fourth alternative, possibilities of large-scale emigration to relieve population pressure, is not actively considered because, even at this early date, opportunities for emigration were confined largely to Europeans.

[3] For a discussion of the circumstances leading to a situation of this sort see Man, Land, & Food, p. (14, 131).

Advances in U.S. agricultural technology up until World War I were largely of a mechanical (labor-saving) nature. They had little influence on yields.

The United States, with its extremely favorable land-man ratio, capitalized on its international comparative advantage in agriculture to earn much of the capital needed to finance its industrialization. Both the expansion of agricultural exports and the release of agricultural labor for industrial development required a rising level of output per person in agriculture.

So long as the supply of new land remained, these two objectives, earning foreign capital and releasing labor for industry, were successfully pursued without raising yields. Also, government policies dating from independence were designed to settle the continent as rapidly as possible. Thus, conditions under which agriculture developed in Japan and the United States were vastly different.

Implications for Less-Developed Countries

The Japanese historical experience is instructive, for many countries now attempting to develop also have little new land that can readily be brought under cultivation. They, too, are essentially fixed-land economies. Included in this group are some of the major less-developed countries such as India, China, and Pakistan. These countries alone contain some 40 percent of the world's people.

Japan's long-term annual rate of yield increase has usually ranged between 1.0 and 1.5 percent per year. Population growth has increased at a similar rate, maintaining a steady level of output per person.

Like Japan, today's less-developed, fixed-land economies must also maintain an annual rate of yield increase that will parallel the annual rate of population increase. Unlike Japan, however, most of today's less-developed countries are experiencing population growth rates nearly double those prevailing over the past several decades in Japan.

Emulation of the spectacular Japanese performance in agriculture will not suffice. If the projected unprecedented population growth rates in the major less-developed countries materialize, the failure to surpass the Japanese performance by a substantial margin would be disastrous.

It is much easier to attain rapid economic development if it can be done before the supply of cultivable land is exhausted. Unfortunately, however, many of the countries now struggling to develop have, as a result of the extremely rapid rates of population growth over the past few decades, reached a point where they no longer have a choice.

As in Japan, governments in these countries must give agriculture the support it needs. Today's less-developed countries, like Japan, must focus their efforts on raising annual output per acre.[4] This is the only way they can raise output per person. It will be at least several years and perhaps several decades before the farm population begins to decline in absolute terms.

The governments of today's less-developed countries must constantly seek new and improved ways of raising output per acre. The obstacles to generating a yield takeoff are great, but the alternatives are so unpleasant as to make the effort absolutely essential.

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[4] See footnote 1, page 70.

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Chapter VIII.--YIELD COMPARISONS

Most of the increases in the world food supply in the remaining decades of this century must come from raising output per acre, because opportunities for expanding the cultivated area in the large, densely populated countries are limited. This chapter, along with preceding chapters and the chapter to follow, provides background for the discussion in chapters X and XI on potentials and prospects for increasing grain yields.

Certain things about yields are evident. The yield per acre must, on the average, considerably exceed the requirements to seed an acre. Thus, man may have made several attempts at planting his own crops before attaining the output levels necessary to sustain a continuing agriculture--one where yields consistently exceeded seed requirements plus the considerable losses that inevitably must have occurred from one season to the next. The precariousness of man's early efforts to develop a controlled food supply is perhaps reflected in the practice still prevailing in many traditional societies of expressing yields as a ratio to the seed used.

In summary, agriculture, as practiced in some parts of the world, has not advanced far beyond that of earliest times. Virtually the entire range of cultural practices developed since man first began the transition from hunter to tiller exists somewhere in the world today.

Rice Yields

Rice, the food staple of a large share of the world's people, is produced mostly by small, subsistence-oriented farmers in Asia. A large part of the total world output is consumed by the producer and his family. Productivity is low, with little rice available for feed. The share of the crop used for feed is probably smaller for rice than for any other grain.

More than 90 percent of the world's rice crop is produced and consumed in Asia. The tonnage entering international trade is quite small, especially when compared with wheat. The only country producing rice primarily for export is the United States, a rather minor producer when compared with the Asian rice-producing countries.

World rice acreage is much less than wheat acreage, but yields are somewhat higher, thus making total output not too different. In terms of calories produced per acre, rice is significantly higher than wheat. But the large quantity of water required for the successful cultivation of rice imposes stringent limits on the possibilities of expanding the area of production.

Rice Yields in Major Producing Countries

The wide variations in rice yields between major producing countries are attributable to several factors. Some of these trace to the existence of two subspecies within the species of rice which is cultivated. These are Oryza sativa subspecies japonica and Oryza sativa subspecies indica. The japonica subspecies is a short-stemmed rice with short, well-rounded grain. The indica subspecies is a taller stemmed rice with long grains, some quite thin.

There are many significant physiological differences between the two subspecies. Perhaps the most significant is that japonica varieties are much more adaptable to intensive cultivation--they are more responsive to fertilizer and do not lodge as badly as the indica varieties.

The rice produced in Japan, North China, Korea, and the Philippines is of the japonica subspecies. Most of that produced in India, South China, and elsewhere on the Asian mainland is of the indica subspecies.

The climatic conditions under which rice is produced are much less varied than with wheat and corn, the other principal grains. The area in which rice can be successfully produced is rigidly defined, often by moisture requirements, but also by temperature and the length of growing season. Virtually all rice is grown by wet rice cultural practices. Thus, attempts are made to keep the moisture level rather constant in all rice-producing countries.

Rice yields are strongly influenced by the level of agricultural technology in the producing countries. Wet rice cultural practices vary widely among countries. In some, such as Japan or Taiwan, nearly all rice fields are irrigated. Elaborate facilities to store and move water, constructed with the investment of human labor over many centuries, are basic to the extraordinarily high yields obtained in Japan. In other countries, such as Burma or Thailand, farmers rely heavily on natural flooding. The heavy monsoon rains are trapped in the paddy fields by bunds (earth dykes or banks) surrounding the fields. Yields in these rainfed paddy fields are susceptible to the unpredictable monsoons, which may bring too little or too much water.

Cultural practices vary widely between major rice-producing countries. Seed is broadcast directly in the field in some countries. In others, seed is sown in a seedbed and seedlings are transplanted into the field at random. In still other countries, seedlings are set in rows to permit inter-row cultivation and easier hand weeding. Labor requirements for the transplanting method are much greater than with direct seeding, but yields are usually substantially higher. The transplanting method is widely used in East Asia. The Japanese paddy method is used extensively in Korea and Taiwan as well as in Japan. The direct-seeding method is still employed in some localized areas on the Indian subcontinent and in the Southeast Asian "rice bowl" countires.

Fertilizer use is reflected in rice yield levels. Japan, Taiwan, and the United States, the countries with the highest yields, use large quantities of fertilizer. Thailand, Cambodia, and the Philippines, countries with very low average yields, use very little. Sustained high yields of rice are not possible without the use of large quantities of chemical fertilizer.

A third factor, in addition to irrigation and fertilizer, which has contributed importantly to the high per acre yields prevailing in some countries, is the replacement of traditional varieties with new, improved varieties. Developing varieties more responsive to chemical fertilizer has been an important part of the rice-breeding programs in many countries, particularly Japan.

In summary, progress in raising rice yields in the more progressive countries has not been generally as dramatic as with corn and wheat. The yield gap between the high- and low-yield countries has gradually widened over the past 25 years (fig. 19). During 1935-39, the ratio between yields in the countries with the highest and lowest yields was 3 to 1; as of 1960-62, the ratio was 4 to 1 and still widening.

Japanese Trend With Comparisions

Japan has been pushing yields steadily upward for several decades. Rice yields today substantially exceed those of any other major rice-producing country--i.e. those having more than 1 million acres in rice. The yield takeoff occurred at a time when the national average yield was just over 2,000 pounds of rough rice (about two-thirds of a ton of milled rice) per acre.

Reliable data on national average rice yields are available only from 1878. The long-term historical yield trend dating back to the middle of the 8th century is based on estimates of yields appearing in Japanese literature. There is no way of testing the

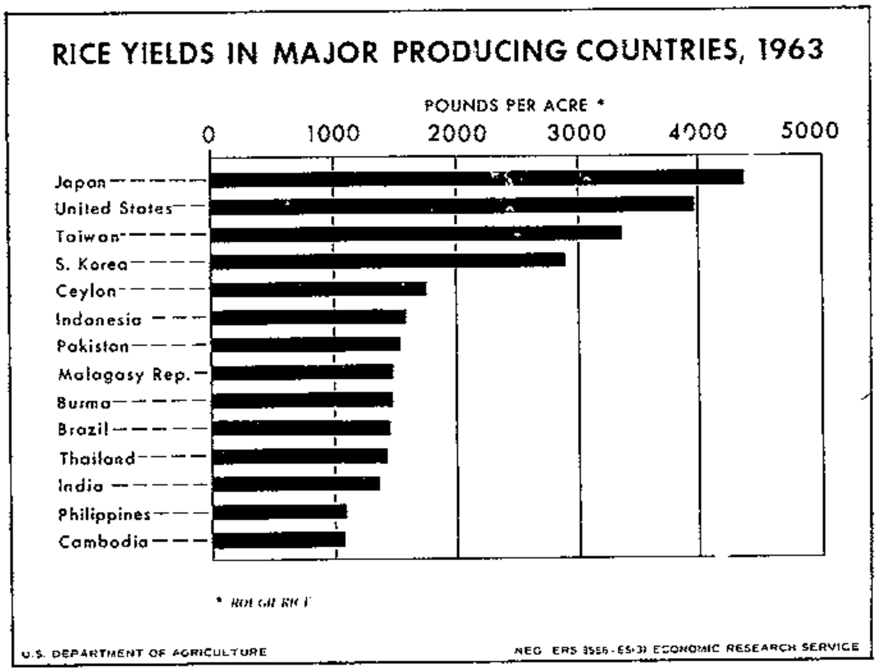

Figure 19

reliability of estimates of rice yields achieved several centuries ago. But on the basis of available knowledge of: (1) the minimal yields required to sustain a continuing agriculture; (2) the yields prevailing during the latter part of the last century, when reliable data first became available; and (3) the rates of yield increase required to reach those yield levels, a reasonable long-term trend, minus short-term fluctuations, can be constructed. This trend appears in figure 20.

Very few of the 13 major rice-producing countries currently have yield levels above those existing in Japan around 1880 at the time of takeoff. Those countries in which current rice yields are above the Japanese pretakeoff level are the United States, Taiwan, and South Korea--all countries with rather small rice acreages. Yield levels in the leading rice-producing countries such as India, Pakistan, and Indonesia are at present still far below Japan's pretakeoff level.

Because the level of rice yields now prevailing in India may have been attained by the Japanese several centuries ago does not mean that it will be several centuries before India attains a yield takeoff.

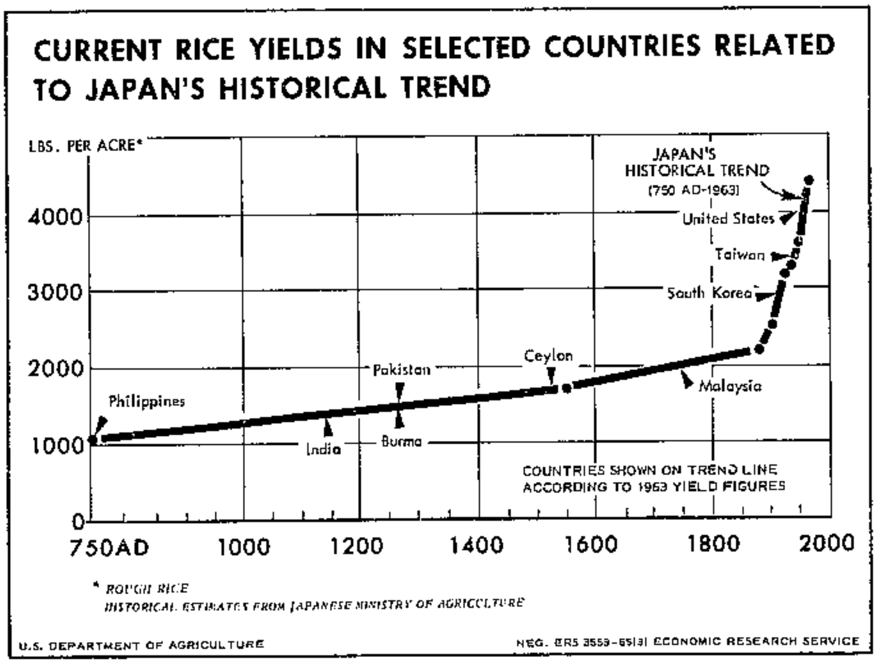

Figure 20

Considerable effort and much time, however, were required to generate a yield takeoff in Japan. Progress in raising yields was never easy or automatic. It required much hard labor and sacrifice.

Generating a yield takeoff requires an abrupt departure from traditional methods of production. New and improved methods of production must be devised and, once devised, adopted. Much trial and error is required--only a few of the new practices introduced will be successful. Developing a yield-raising capability requires a continuing flow of new practices and a steadily rising volume of capital inputs per acre. Even with the most fortunate of circumstances, progress is often painfully slow.

Data for the last several years indicate that Taiwan, the beneficiary of both Japanese agricultural methods and large-scale U.S. technical assistance, has achieved a yield takeoff. But the major producing countries, such as India, Mainland China, Pakistan, and Indonesia, do not yet appear to be on the verge of takeoff. For some of the major rice-producing countries, takeoff may still be some distance in the future.

Wheat Yields

Wheat provides man with one-fifth of his food energy supply. It is by far the most widely grown of the 3 major grains. The principal food staple in nearly all the high-income countries, it is grown and consumed in nearly every country in the world. Even the countries depending heavily on rice, such as India, Mainland China, and Japan, also consume sizable quantities of wheat. In many rice-consuming countries, per capita wheat consumption is rising faster than per capita rice consumption. This may be due partly to a need to diversify diets and partly to a desire to emulate Western food consumption habits.

Wheat has both a higher protein content and a higher quality protein than rice. It is widely adaptable in terms of moisture, temperature, length of day, and growing season. One of the first crops domesticated, it probably originated somewhere in the Middle East.

Wheat is easily the most widely traded grain, with the tonnage traded exceeding that of all other grains combined. The 3 principal exporting countries--the United States, Canada, and Australia--produce primarily for export. Only a minor part of each year's crop is retained for domestic use in Canada and Australia.

Wheat Yields in Major Producing Countries

Major producing countries are defined as those with 2 million acres or more in wheat. According to this criterion, 27 countries rank as major producers. Acreages in this group ranged from just over 2 million acres in such countries as the United Kingdom and Mexico to 168 million acres in the Soviet Union.

Two factors strongly influence yields of wheat--the amount (and seasonal distribution) of rainfall and the level of agricultural technology. Countries with low average rainfall tend to have low yields and countries with high average rainfall, high yields. Countries with a combination of traditional agriculture and semi-arid growing conditions have extremely low yields, frequently averaging less than 10 bushels per acre (fig. 21).

Wheat yields in Tunisia, over the past 8 years, have averaged less than 6 bushels per acre. Allowing for seed requirements and losses in storage, net returns per acre have been minimal; returns of this level cannot have greatly exceeded returns to the earliest cultivators. Nor is Tunisia alone with its unfortunately low yields. Yields in Syria and Brazil average only 9 to 10 bushels per acre.

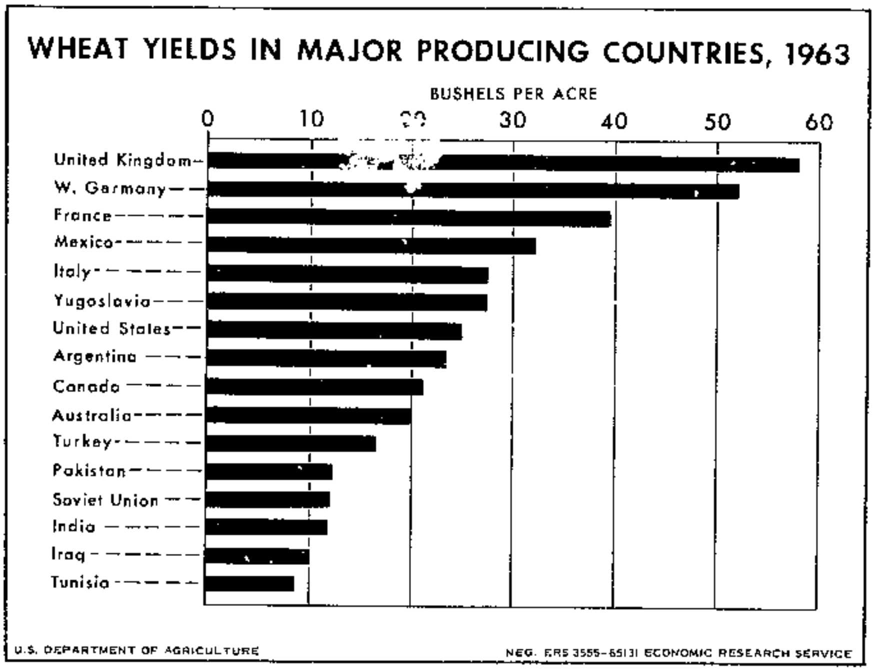

Figure 21

Countries with the combination of high average rainfall and an advanced agricultural technology consistently attain very high yields. Countries such as the United Kingdom and West Germany, where yields have averaged from 50 to 60 bushels per acre, are included in this group.

Average wheat yields, during the 1935-39 period in those countries with 2 million acres of wheat or more, ranged from 7 to 35 bushels per acre. Yields climbed rapidly, however, in those countries which achieved a yield takeoff, and the ratio between yields in the high-yield and low-yield countries increased from the 5-to-1 ratio before World War II to 8 to 1 by 1962. Some countries, mostly less-developed, did not improve yields at all; Included in this group were Brazil, Iraq, and the Soviet Union.

The 3 major exporting countries--the United States, Canada, and Australia--produce most of their wheat in low average rainfall areas. Opportunities for irrigating wheatlands do not exist to any great extent, except in a few less important producers, such as Egypt and Mexico where rivers flow through, or are adjacent to, the semiarid wheat growing regions.

Wheat responds well to moisture, as evidenced in the high yields prevailing in northwestern Europe, but it is also one of the most drought-resistant of all the grains. Wheat is the only one of the 3 major grains adapted to either low rainfall conditions or the northern latitudes. Thus, it plays a key role in utilizing the earth's land resources to the fullest.

U. K. Trend With Comparisons

Wheat yields in the United Kingdom today are higher than in any other major wheat-producing country. Available evidence indicates that per acre wheat yields have been trending gradually upward over the past several centuries (fig. 22). Only since the late 1930's, however, have yields gained rapidly. Prior to that time, even the cumulative gains made over the course of any given century were probably so meager as to be scarcely perceptible.

Current yield levels in the low-rainfall, less-developed countries were attained in the United Kingdom several centuries ago. Yield levels at the time of the industrial revolution were quite high, comparing favorably with those existing in Canada today. Thus, it would appear that the natural advantages of the United Kingdom in producing wheat were considerable. Even when it was a traditional society, wholly lacking in modern technology, yields were surprisingly good, far exceeding those prevailing in many countries today.

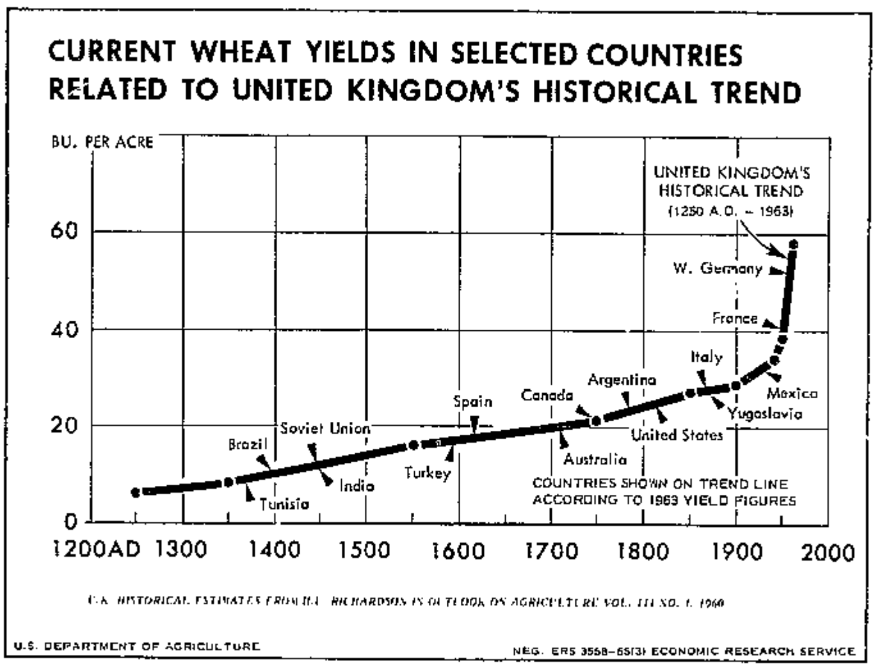

Figure 22

Corn Yields

The corn plant, domesticated by the Indians of Central America, has been cultivated for at least a few thousand years but perhaps not as long as wheat or rice. It played an important role in the development of the pre-Colombian Indian civilizations of Latin America. By the time of the discovery of the New World, the cultivation of corn was quite advanced, reflecting at least several centuries of seed selection and evolution of cultural practices.

Corn is the only 1 of the 3 principal grains widely used as both a food grain and a feed grain, and it is the only 1 of the 3 that originated in the New World. Although corn production is now widely disseminated throughout the world, the greater part of the world corn crop is still produced in the Western Hemisphere, mostly the United States.

In the northern part of the Western Hemisphere, corn is largely a feed grain, but in the central and southern part it is a food grain. In Africa and Asia, most of the corn produced is consumed as food. It is an important food staple in both Africa and Latin America, supplying nearly half of the total calorie supply in some countries. As a foodstuff, corn is generally considered inferior to wheat or rice in most cultures. As incomes rise, direct consumption declines, and indirect consumption in the form of meat, milk, and eggs rises.

Corn ranks second to wheat in terms of the quantity entering world trade channels. Its importance in both production and trade is growing steadily, largely as a result of the increasing consumption of poultry and livestock products.

Corn Yields in Major Producing Countries

Corn is grown under rather uniform climatic conditions throughout the world. It requires high temperatures, high rainfall, and a fairly long growing season. Thus, the area in which it can be successfully cultivated is limited, compared with wheat, a much more adaptable crop in most respects.

The United States-Canadian border approximates the northern limit of the corn-growing region in North America. Canada, though it has a large total grain acreage, has less than half a million acres of corn, compared with 57 million acres in the United States. Corn produced for grain in Europe is grown largely in the Mediterranean countries.

Some 23 countries rank as major producers, with 1 million acres or more. In some countries where corn yields are lowest, they have been trending downward in recent years. Brazil, Guatemala, Indonesia, and the United Arab Republic (Egypt) are in this group. In such countries as the United States, where corn yields are highest, yields are rising rapidly. The yield gap between those countries which have achieved a yield takeoff and those where yields are static or declining is steadily widening.

The yield ratio between the major corn-producing countries with the highest and lowest average corn yields during the 1935-39 period was not more than 4 to 1. As of 1960-62, the ratio was 6 to 1 (fig. 23).

The United States has both the largest acreage and highest yield. This is unusual because countries with higher yields usually have smaller acreages. Countries with very large acreages usually have such a wide diversity of growing conditions that it is difficult to attain high average yields.

The midwestern part of the United States, commonly referred to as the Corn Belt, is favored with near-ideal climate and soils for corn production. These conditions, supplemented by vastly improved hybrid seed, large quantities of fertilizer (especially nitrogen), and advanced tillage practices, have resulted in yields far above those found anywhere else in the world.

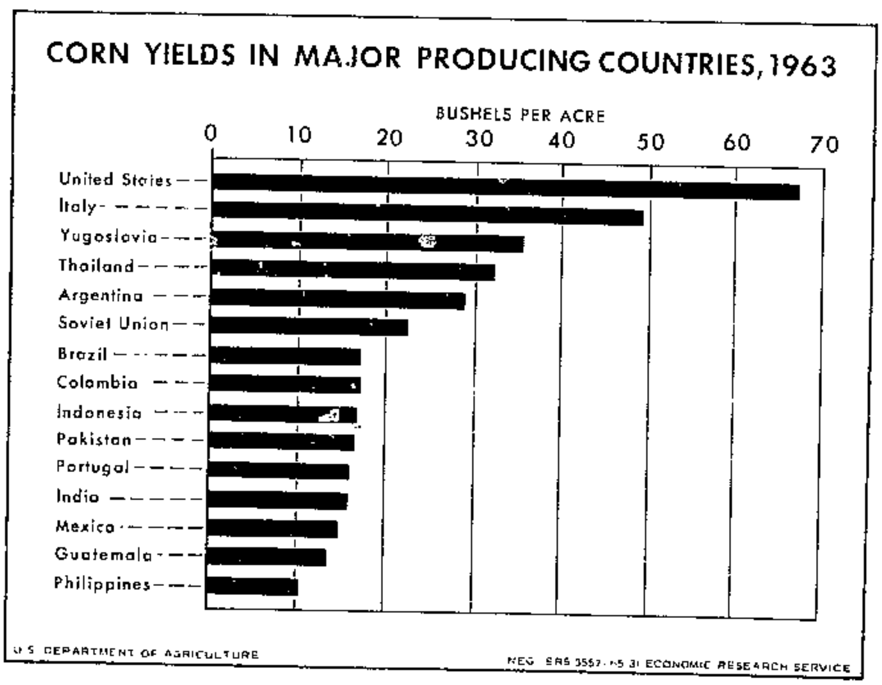

Figure 23

U.S. Trend With Comparisons

The art of corn cultivation advanced considerably under the New World Indians during the many centuries lapsing between the domestication of the corn plant and the arrival of the white man. The Indians had developed several improved practices which they passed on to the white man. They taught the white man to fertilize with fish and to intertill. European farmers at this time had only the small grains, which were seeded by broadcasting and hence did not require intertilling (tilling between rows).

The Indians, like more primitive agrarian people everywhere, practiced land rotation; they farmed a plot of land for a few years and when its natural fertility declined, they moved on to a new spot. The Indians did not have any draft animals or, for that matter, livestock of any kind. Nor did they have the wheel or metals. Theirs was a wood, stone, and bone technology.

The early settlers introduced the English plow and draft animals, which undoubtedly enabled them to prepare a better seedbed than the Indians had. They combined crop and livestock production, using the manure for fertilizer. They developed crop rotations and also did considerable further selecting and improving of seed. Forms of fertilizer other than livestock manure were also brought into use.

Corn yields prevailing among the North American Indians when Columbus discovered the New World were probably not much below 10 bushels per acre and probably not much above 20 bushels per acre. If corn yields averaged 15 bushels per acre, they were not too different from those in some less-advanced countries today.

In summary, the available evidence indicates that the Indians had some success in raising yields before Columbus came and that the early settlers had considerable further success during the centuries between 1620 and 1800. As of 1800, the earliest date for which reliable estimates are available, yields averaged 25 bushels per acre. The U.S. yield average changed little from 1800 to 1940, but between 1940 and 1960 it doubled (fig. 24). Over the 160-year span, corn yields were essentially static for 140 years, then rose very rapidly for 20 years.

In 1962, the United States had by far the highest corn yield of any major producing country. Only 7 of the 22 major producing countries (1 million acres or more) had achieved yields in 1962 above those existing in the United States in 1800. Yields in 4 countries were below the estimated yield levels prevailing among the Indians when Columbus arrived in the New World.

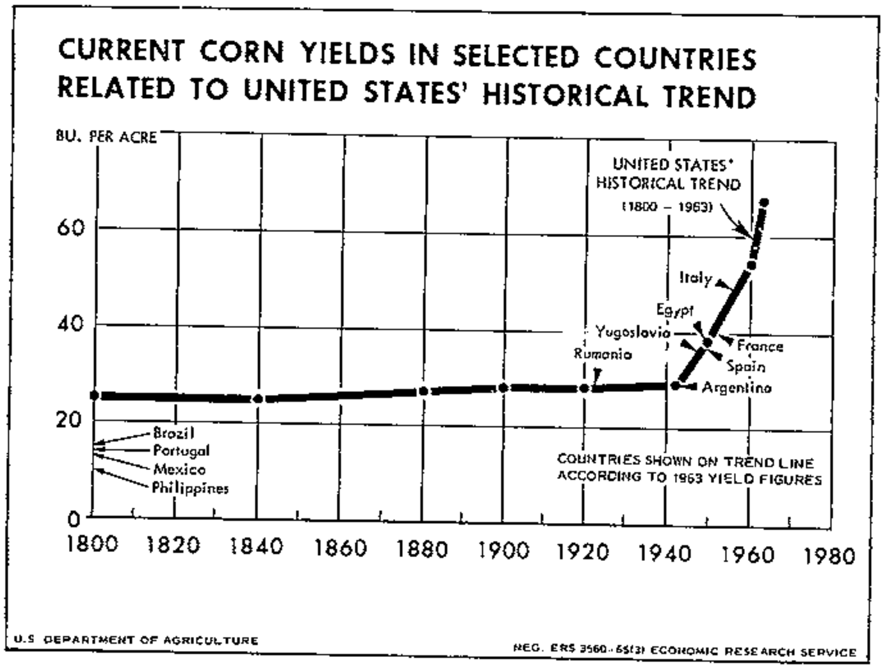

Figure 24

As recently as 1935-39, several major corn-producing countries had yields well above those of the United States. Included in this group were Argentina, France, Italy, Spain, Hungary, Yugoslavia, and Egypt. Few of these countries were able to generate a yield takeoff, however, and by 1962 yields in most of these countries were scarcely half those in the United States. France and Italy, two of the countries with corn yield levels closest to those of the United States, have made much progress in raising yields over the past several years, both apparently having successfully generated yield takeoffs. Trends in wheat yields in these two countries also indicate a yield takeoff.

Some countries with 1935-39 yields above those of the United States have made little or no progress in raising yields since that time. Argentina and Hungary are in this group. Corn yields per acre in Egypt, the only major producing country with its entire corn acreage under irrigation, have declined since 1935-39.

At present there is no indication that the current phenomenal rate of increase in corn yields in the United States will slacken appreciably. The gap between yield levels in the United States and pretakeoff corn-producing countries should continue to grow.

Chapter IX.--INVENTORY OF YIELD-INCREASING PRACTICES

Multiple-Cropping

Multiple-cropping may be defined as growing more than 1 crop per acre per year. The science of multiple-cropping is highly developed in some countries, particularly in eastern Asia. The index of multiple-cropping is highest in Taiwan, where farmers get an average of nearly 2 crops per acre per year. Multiple-cropping is also widely practiced in Japan and Korea, where 50 to 60 percent of the cropland produces 2 crops; Mainland China gets 2 crops on 40 percent of its farmland. India, on the other hand, lags, for only 20 to 25 percent of the land grows 2 crops.

Any one of several physical factors can limit the area producing more than one crop. Temperature limitations are perhaps the most common. Much of the currently developed world is situated in the Temperate Zone. Winter temperatures in this region are so severe that only the most hardy crops can survive. Not only are winters severe, but in the higher latitudes of the North Temperate Zone, the summer growing season is quite short, permitting only short-season crops.

In the middle latitudes, where year-round temperatures are milder, rainfall may be a limiting factor, at least for part of the year. Many areas in the tropics with relatively warm year-round temperatures have monsoonal climates, characterized by heavy summer rainy seasons followed by an annual dry season of several months' duration. The wet season is ideal for rice cultivation, but crops can be successfully grown during the dry season only if irrigation is available.

Multiple-cropping is a practice deserving considerable attention as it becomes necessary to obtain a greater output from a limited amount of land. Multiple-cropping is not, however, a simple matter of just planting more than 1 crop per year. It requires substantially greater inputs of capital and labor and more sophisticated management practices. Labor and some capital inputs are often more efficiently used--seasonal unemployment is reduced, and draft animals can be utilized more fully the year around.

To what extent multiple-cropping is possible and practical in parts of the less-developed world where it is not now practiced is difficult to say. The availability of capital inputs such as fertilizer must increase and management techniques must be improved before any significant advances can be made.

Fallowing

Fallowing may be defined as a system of cropping resulting in less than 1 crop per acre per year. It is the opposite of multiple-cropping, which results in more than one crop per year. Fallowing has various purposes. In most areas it is a moisture-conserving device, but in some limited areas its purpose is to restore soil fertility.[1] And under some circumstances, it is employed as a pest or weed control measure.

This discussion will focus on fallowing as a moisture-conserving device. Moisture loss from bare fallow land is much less than from land with a crop on it. Fallowing permits the extension of cultivation into areas with marginal rainfall. Without fallowing, soil moisture in many areas would be reduced to the point where crop failures would become quite frequent, forcing abandonment.

Fallowing is not always a yield-raising technique. Yields may be calculated in terms of total crop area, including both land planted and land in fallow in any given year, or in terms of planted area alone. Calculated in terms of planted area alone, fallowing is a yield-raising technique. But if annual output per acre is calculated by dividing output by total acreage, both planted and fallow, fallowing may not be a yield-raising practice. If rainfall is sufficiently low that cultivation would not be possible without fallowing, then it is a yield-increasing practice, however calculated.

Fallowing is closely associated with wheat production. Just as most of the world's irrigated land is concentrated in rice-growing regions, so most of the world's fallowed land is concentrated in wheat-growing regions. Some fallowed land is used for production of other small grains such as barley, oats, and grain sorghum, but by far the greater part is used for wheat. Fallowing varies in

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[1] Fallowing to restore soil fertility, practiced mostly by tribal cultivators, is confined largely to the tropics. Land, after being cleared, is farmed for 2 or 3 years until fertility declines. It is then abandoned for several years, sometimes as much as 20 or 30 years, before the tribe returns. This type of cultivation, often called "shifting cultivation," is practiced in the interior of Brazil, parts of Sub-Sahara Africa, and in various locations in Southeast Asia including part of the Philippines, the outer islands of Indonesia, and the interior of the Indochina peninsula.

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INCREASING WORLD FOOD OUTPUT: PROBLEMS AND PROSPECTS. (Foreign Agricultural Economic Report). / Lester R. Brown. Washington, DC: Economic Research Service. Apr. 1965.

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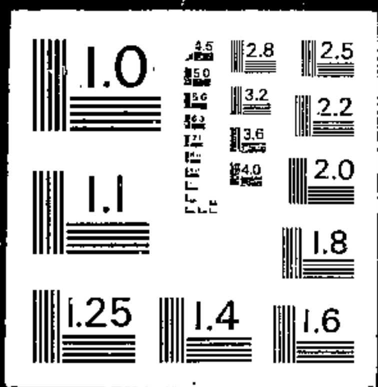

intensity. In some areas, land is fallowed every second year; in areas with more favorable rainfall, every third year.

The principal areas of fallow are in the major wheat-producing countries such as Canada, the United States, (table 20) Australia, (table 21) and the Soviet Union. Fallowing is an established part of wheat growing in Canada. Area in fallow in some years closely approaches the area in wheat. All but a small portion of the wheat produced in Canada is spring wheat--wheat sown in the spring and harvested in the fall. And most of it is grown on land that is summer-fallowed every second or third year, depending on rainfall.

Australia's farmers early discovered the value of bare fallow in producing wheat on their low-rainfall continent. During the last half of the 19th century, when the few million acres in wheat were concentrated along the coast, only one-tenth to one-fourth of the wheat land was in fallow in any given year. By 1925, as the wheat area expanded inland into the lower average rainfall regions, 1 acre of every 3 was in fallow. Since 1925, the area in fallow has

Table 20.--United States: Area of summer fallow and area of wheat sown, 1910-62

Year	Cultivated summer fallow[1]	Area of wheat sown	Fallow per 100 acres wheat sown[2]
	Million acres	Million acres	Acres
1910	4	45.8	8.7
1911-15	5	53.2	9.4
1916-20	5	59.5	8.4
1921-25	6	63.4	9.5
1926-30	10	66.5	15.0
1931-35	14	67.1	20.9
1936-40	20	71.7	27.9
1941-45	18	61.4	29.3
1946-50	23	76.7	30.0
1951-55	28	71.3	39.3
1956-60	30	55.6	54.0
1961-62	31	52.4	59.2

[1] The practice of fallowing is confined largely to the regions west of the Mississippi River and is especially prevalent in Great Plains states.

[2] Although most summer-fallowed land is planted to wheat the following year, a small part is used for other crops such as barley and grain sorghums.

Source: (29), and (92).

To what extent multiple-cropping is possible and practical in parts of the less-developed world where it is not now practiced is difficult to say. The availability of capital inputs such as fertilizer must increase and management techniques must be improved before any significant advances can be made.

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Table 21.--Australia: Area in fallow and area in grain, selected years, 1860-1961

Year	Area in fallow	Area in grain	Fallow per 100 acres of grain
	Million acres	Million acres	Million acres
1860...	.1	.8	12.5
1865...	.1	1.1	9.1
1870...	.2	1.5	13.3
1875...	.4	1.8	22.2
1880...	.7	3.5	20.0
1885...	.7	3.6	19.4
1890...	1.0	3.9	25.6
1895...	.9	4.3	20.9
1900...	1.6	6.6	24.2
1905...	2.4	7.0	34.3
1910...	3.4	8.6	39.5
1915...	4.0	13.7	29.2
1920...	4.7	10.6	44.3
1925...	7.1	11.9	59.7
1930...	9.2	19.9	46.2
1935...	9.8	14.4	68.1
1940...	8.6	15.5	55.5
1945...	[1] 8.6	14.3	60.1
1950...	[2] 8.5	14.7	57.8
1955...	6.4	15.6	41.0
1960...	7.4	20.1	36.8
1961...	8.0	19.5	41.0

[1] Estimate based on incomplete data.
[2] Data for 1949.

Source: (5).

rather consistently ranged between one-third and one-fourth of the total wheat area.

Fallowing in the United States is confined almost entirely to the low average rainfall, wheat-producing areas west of the Mississippi. The historical relationship between the area in wheat and area in fallow closely parallels that of Australia. In 1910, the area in fallow was less than one-tenth of the total wheat-producing area. During the 1930's, it represented about one-fifth of the total wheat-producing area. In the postwar period, the area in fallow expanded further, exceeding one-third during the late 1950's and early 1960's.

The Soviet Union is one of the few advanced countries that has failed to raise wheat yields over the past several years. Average wheat yields in 1960-62, at 11.9 bushels per acre, were exactly the same as in 1935-39. The area in fallow declined sharply during this period, especially over the last decade. Some 73 million acres were in fallow in 1953, but by 1963 this had been reduced to 13 million acres (84, p. 56 f.). The sharply reduced wheat crop of 1963 indicates that the reduction in fallowed land may have taken its toll.

In summary, the practice of fallowing has made possible the cultivation of land not otherwise cultivable. Sometimes fallowing is a yield-raising technique; at other times it is not. It is, however, an integral and essential part of dryland farming as practiced in many parts of the world.

Irrigation and Drainage

Irrigation is much more widely used in some regions than in others. Western Europe, favored with an abundance of rainfall well distributed throughout the year, has relatively little irrigated land. Asia, on the other hand, is very much dependent on irrigation, (table 22). Rice, supplying 40 percent of the region's total food energy supply, is grown almost entirely on either irrigated land or rain-fed paddy fields. China and India together have more than half the world's irrigated land.

Egypt, which with the Sudan has most of the irrigated land in Africa, is the only country in the world with virtually all of its cropland under irrigation. Because of this, yields of Egypt's major crops are far above those in most other less-developed countries.

Spain, with its semiarid Mediterranean climate, has more irrigated land than all the other West European countries combined. The Soviet Union has the major portion of the irrigated land in Eastern Europe.

The United States, with large areas of cultivated land in the Southwest almost entirely dependent on irrigation, has by far the largest irrigated area of any country in the Western Hemisphere. Mexico ranks next, followed by Argentina, Chile, and Peru. Australia, with a very small area under irrigation, is unique, for unlike most large land bodies, it has no large rivers, and therefore, limited potential for irrigation.

One crop--rice--monopolizes the world's irrigated land. Precise data are not available, but it is certain that rice occupies far more irrigated land than all other crops combined. It is the only major crop produced largely under irrigation. Because rice production is so dependent on irrigation, the possibilities for expanding the area in rice production are limited by the potential for expanding the area under irrigation.

Table 22.--Area of irrigated land in selected countries, selected years, 1950-62

Country	1950	1953	1956	1959	1962
	- - - - - - - - - 1,000 acres - - - - - - - - - -				
North America					
Canada..................	--	628	628	--	--
United States...........	26,427	--	--	27,957	--
Latin America					
Argentina...............	--	3,583	3,706	--	--
Bolivia.................	124	--	158	--	--
Brazil..................	326	348	348	--	--
Chile...................	3,212	3,366	3,368	--	--
Colombia................	180	--	1,248	--	--
Mexico..................	5,199	6,187	6,187	--	--
Paraguay................	30	30	30	17	17
Peru....................	2,965	2,995	2,995	--	--
Venezuela...............	--	544	608	--	--
Western Europe					
France..................	27	47	57	79	77
Greece..................	--	704	840	988	1,112
Italy...................	353	435	341	336	294
Portugal................	67	82	96	89	91
Spain...................	--	--	4,240	4,413	5,014
E. Europe and U.S.S.R.....					
Bulgaria................	--	618	--	981	--
Hungary.................	--	67	220	180	544
Rumania.................	--	--	230	339	472
U.S.S.R.................	--	--	--	--	23,450
Yugoslavia..............	--	--	252	220	343
Africa					
Algeria.................	--	119	--	618	--
U.A.R. (Egypt)..........	--	6,360	6,449	6,089	--
Ethiopia................	25	37	116	74	--
Malagasy Republic.......	652	652	--	1,769	--
Morocco.................	--	148	--	232	--
Somalia.................	--	227	319	393	--
Sudan...................	--	--	--	--	--
Asia					
Burma...................	1,240	1,339	1,280	1,240	1,408
Ceylon..................	452	487	546	630	909
India...................	--	52,405	56,235	57,824	--
Indonesia...............	11,811	12,577	14,087	14,667	--
Iran....................	3,706	3,954	--	6,820	--
Iraq....................	4,324	7,196	6,919	9,081	--
Israel..................	109	178	262	311	348
Japan...................	7,055	7,047	--	--	--
Jordan..................	--	79	188	124	136
Korea (South)...........	--	--	1,315	1,554	1,670
Lebanon.................	119	119	175	175	175
Malayasia...............	321	--	474	521	546
Pakistan................	22,711	22,182	23,489	27,354	--
Philippines.............	1,280	1,863	2,157	1,641	--
Syria...................	976	1,258	1,685	1,176	--
Thailand................	1,485	--	3,151	3,800	4,641
Turkey..................	198	--	4,843	--	--
Oceania					
Australia...............	1,512	1,473	1,270	1,905	2,473
New Zealand.............	106	111	--	166	--

Source: (14)

In many areas of the world, the failure to consider drainage when planning or operating irrigation systems has been very costly. Neglect of the drainage requirements of irrigated areas has resulted in the loss of millions of acres to waterlogging and salinity in the last few years alone. This is particularly true where rivers have served as the source of irrigation water. River water, often flowing from snow-fed mountain areas to the ocean, has been diverted onto the land through elaborate irrigation systems. Part of the water thus diverted is used by the growing crops, part is lost through evaporation, and part percolates downward.

Over the course of many decades and centuries, the water percolating downward has gradually raised the water table until in many areas it is within a few feet of the surface. Once the water table reaches this level, 2 things happen. The lower roots of the growing crops either fail to develop or die because of the lack of oxygen. At the same time, evaporation from the high-level water table results in a concentration of salts, often toxic to plants, in the upper soil strata. These 2 problems are often referred to jointly as the waterlogging and salinity problem.

Some of the river irrigation systems plagued with this problem are the Indus, Ganges, and Tigris-Euphrates. The problem in West Pakistan, dependent upon water from the Indus River for most of its farmland, is perhaps most acute. It is estimated that as much as half of the land in West Pakistan is affected to some extent by waterlogging and salinity (72, p. 68). Thus, at a time when substantial progress is being made in expanding the irrigated area in some parts of the world, the area irrigated and the effectiveness of irrigation is declining in other areas.

The value of irrigation as a source of increased yields is considerable. In many areas, the difference between irrigated and unirrigated land is the difference between land that is cultivated and land that is not. Irrigation not only contributes directly to higher yields but also expands the possibilities for additional use of other yield-raising inputs, such as fertilizer. Irrigation is also essential to any increase in multiple cropping in many parts of the world, particularly those which have a long dry season.

The uncommonly high yields achieved in Japan are due in large part to the high percentage of irrigated land and the greater use of other inputs made possible by the widespread availability of water. The spectacular success in raising wheat yields in Mexico is due in large part to the shifting of a large part of the wheat acreage onto irrigated land.

In viewing future prospects for increasing food output, it must be recognized that whereas most yield-raising inputs such as fertilizer, improved seed, and pesticides can be increased several-fold, world-wide possibilities for expanding the area under irrigation in the foreseeable future amount to only a small fraction of the area now under irrigation.

A look at irrigation in the future must focus on two things--the potential for expanding the irrigated area and the cost of expansion. The importance of irrigation and the potential for expanding the area under irrigation are discussed by Herbert Addison, a hydraulic engineer with a lifetime of experience, in his book, Land, Water and Food (1, p. 268). He sets forth the following 3 conclusions regarding the historical progress and present and future state of land reclamation:

(1) Less than 10 percent of present world food production comes from irrigated or artificially drained land.
(2) Less than 5 percent of this total food supply depends upon the control of water on an engineering scale.
(3) Of the estimated increase in world food production during the next half-century, not more than one-tenth of this total can be expected as a result of new large-scale engineering works.

The area of land under irrigation cannot be greatly expanded with present technology. Continuing progress in lowering both the cost of desalinization of sea water and the cost of atomic power, however, will undoubtedly expand the potentially irrigable land area. Despite the progress made in reducing the cost of desalinization, the cost must be reduced to a very small fraction of the present level before widespread use for irrigation is possible.

A source of power more economical than any now existing will be needed to pump the water inland to food-producing areas. Atomic energy will in all probability be produced at a cost low enough to consider its use for this purpose. Just as crude petroleum is now pumped hundreds of miles from the interior of the Sahara to the Mediterranean coast in huge pipelines, so desalted water may be pumped from the Mediterranean deep into the interior of North Africa. But this is still far in the future. It will not alleviate the food shortage facing this generation.

Agricultural Chemicals

Fertilizer

When food output could be increased by simply expanding the area under cultivation, chemical fertilizers were useful but not essential. But as it becomes necessary to look more and more to rising yields for additions to the food supply, fertilizer becomes an indispensable yield-raising input.

World consumption of chemical fertilizers has increased steadily over the past quarter century. Total consumption in terms of plant nutrients (N, P_2O_5 and K_2O) was 10 million tons in 1938, 15 million tons in 1950, and 29 million tons in 1960 (table 23). Nearly 24 million tons of the 29-million-ton total was consumed in the developed regions.

During the past quarter century, 2 geographic regions--North America and Western Europe--completed the transition from the area-expanding method of increasing food output to the yield-raising method. Food output increased dramatically in both regions, but the acreage in crops actually declined. These regions, however, accounted for nearly two-thirds of the world's steadily increasing fertilizer consumption throughout this period.

It is not possible to say what part of the food output in the developed regions is attributable to chemical fertilizer, but it is a substantial and growing part. In the less-developed regions, however, where rates of applications are quite low, fertilizer currently accounts for only a very small part of total food output.

Many factors influence the effectiveness of fertilizer as a yield-raising capital input. Among these are physical and physiological

Table 23.-- Consumption of chemical fertilizers (N, P_2O_5 and K_2O), by regions, 1938, 1950/51, and 1960/61

Region	1938	1950/51	1960/61
		1,000 metric tons	
Geographic regions			
North America	1,416	4,700	7,541
Latin America	82	290	999
Western Europe	4,119	5,814	9,998
E. Europe and U.S.S.R.	2,544	2,087	5,127
Africa	200	360	720
Asia[1]	1,030	1,070	3,290
Oceania	380	530	930
World	9,771	14,851	28,605
Economic regions			
Developed regions[2]	8,459	13,121	23,596
Less-developed regions[1]	1,312	1,720	5,009

[1] Excludes Mainland China, but amount of chemical fertilizer used by this country is not large in relation to the regional total.
[2] Includes North America, Western Europe, Eastern Europe and the U.S.S.R., and Oceania.

Source: Taken from (14), table 34, p. 105.

factors such as type and quantity used, method and timing of application, type of soil, available moisture, prevailing temperatures, and responsiveness to fertilizer of the varieties used.

Moisture is essential if fertilizer applied to the soil is to become available to plants. Both the amount and annual distribution of rainfall throughout the year influence the effectiveness of fertilizer. Where rainfall is limited to a few months of the year, as in the monsoonal regions, leaching and loss through runoff may be a serious problem.

Perhaps the most frustrating factor limiting the effectiveness of fertilizer in less-developed countries is the lack of responsiveness of traditional, indigenous varieties of crops to chemical fertilizer. Virtually all varieties of the major crops now produced in the developed regions have been developed since fertilizer use has become widespread. Responsiveness to chemical fertilizer has been incorporated into plant selection and breeding programs.

Mellor and Herdt, in a recent study (65) compared rice-nitrogen experiments in India and the United States. They point out the wide differences in responsiveness of the varieties grown in the 2 countries. Using a broad base of experimental data from 2 leading rice-producing States in the United States (Arkansas and Texas) and in India (Orissa and West Bengal), they show both the much lower response at all levels of fertilizer use and the much lower rate of application at which maximum yields are attained in India. Maximum yields in India were attained at about 40 pounds of nitrogen per acre, whereas in the United States they continued to climb until rates of application reached 120 pounds per acre. The authors discuss many other factors which could influence the different levels of responsiveness, such as soils and production practices, but conclude that inherent responsiveness to nitrogen is probably an important factor, (65, p. 153).

Fertilizer-responsive varieties grown in one area cannot always be successfully transferred to another area. Any one of several factors such as variations in soils, temperature, length of growing season, day length, and the preferences of local consumers may prevent this.

In addition to the physical and physiological factors influencing the effectiveness and therefore the use of fertilizer, the economic relationships surrounding its use also affect the extent of its use as a yield-raising input (table 24). The price per pound of fertilizer paid by farmers in less-developed countries is invariably higher than the price paid in developed countries.[2] And farm prices of

[2] See chapter X for a discussion of the factors affecting costs of yield-raising capital inputs in less-developed economies.

Table 24.--Cropland harvested, fertilizer used, and average rate of application, United States, 1910-62

Period	Cropland harvested	Fertilizer used[1]	Average rate of application[2]
	Million acres	Thousand tons	Pounds
1910........	317	856	5.4
1911-15......	325	950	5.8
1916-20......	346	910	5.3
1921-25......	348	1,033	5.9
1926-30......	353	1,385	7.8
1931-35......	336	1,043	6.2
1936-40......	329	1,576	9.6
1941-45......	344	2,353	13.7
1946-50......	345	3,547	20.6
1951-55......	338	5,518	32.7
1956-60......	317	6,764	42.7
1961-62......	292	8,122	55.6

[1] In terms of plant nutrients--N, P_2O_5 and K_2O.
[2] Fertilizer used divided by cropland harvested.

Source: (29).

foodstuffs are usually lower than those in developed countries. The contrasting fertilizer costs and rice prices for the United States and India cited in the article by Mellor and Herdt (65) are probably not unusual. The cost of nitrogen to farmers was 16.7 cents per pound in the United States and 22.8 cents per pound in India; the price of rice was 4.60 cents per pound in the United States and 2.84 cents per pound in India (65, p. 156). In addition to getting less additional rice per pound of fertilizer because of lower responsiveness of indigenous varieties, Indian rice farmers are also faced with a much less profitable fertilizer-cost/rice-price relationship. The combined effect of these factors, which are common to most less-developed countries, serves to reduce the amount of fertilizer used and hence the potential for raising yields.

Fortunately for the less-developed countries, these constraints on the use of fertilizer can be reduced. Fertilizer-responsive varieties which are adapted to local conditions can be developed, but development will take time. Price policies can be shaped by government to make the cost-price relationship more conducive to the use of fertilizer.

Pesticides

Several capital inputs tend to complement each other. The lack of any one of the inputs in this group may seriously reduce the effectiveness of the others. Pesticides is one of this group.

The term "pesticides" in its broadest sense includes such things as insecticides, fungicides, and herbicides. Insecticides and fungicides may be grouped with those capital inputs usually described as yield-increasing; herbicides are more often labor-saving. Where labor is plentiful and inexpensive, as in most underdeveloped countries, it may not only be possible but also more economical to weed by hand.

The contribution pesticides can make toward expanding output varies widely with crops and conditions. Crop failures would undoubtedly be commonplace in many places were it not for chemical pest control. In other areas, the lack of pesticides would not greatly reduce output.

The use of pesticides in less-developed countries is limited by the same cost-price factors limiting the use of fertilizer and other capital inputs. Another limitation is the lack of research on plant pests in tropical and subtropical regions; the great bulk of pesticide research is conducted in the developed Temperate-Zone countries. And application of the pesticides developed in the advanced countries often requires high-pressure sprayers not generally found in the less-developed economies.

Improved Varieties

The term "improved varieties" can mean many things. Used in this report in its most general sense, it implies a greater response to a given level of inputs. The term often means improved with respect to a specific characteristic. This may mean a stronger stem in grains to reduce lodging, a greater response to fertilizer, or earlier maturity to permit cultivation in higher latitudes.

The most economic way to cope with some plant production problems may often be by plant breeding, i.e., by developing an improved strain or variety. It may be less costly to develop a disease-resistant variety than to eradicate the disease.

In many advanced countries, plant breeding programs have become partly maintenance operations. Stated otherwise, in countries where agriculture is quite advanced, a certain minimal investment in plant breeding is required just to prevent yields from declining. A new variety, resistant to a newly introduced disease, may be needed to prevent a decline in yields. This is, in a sense, the price which must be paid for having large areas of specialized production and rapid transport facilities. Both make agriculture more vulnerable to insect and disease pests.

Plant breeding and selection programs are long-term continuing programs. Useful varietal improvements are evolutionary and cumulative; they become available gradually over a long period of time. Once a breakthrough in the improvement process has been made, it may be several years before farmers learn of it, and become convinced of its worth. The development of hybrid corn in the United States is a classic example of an improved seed. The advantages of increased yields of hybrid corn seem obvious, yet, it required America's relatively progressive farmers about 2 decades to accept hybrid seed corn completely (fig. 25).

As increased reliance is placed on raising yields, improved varieties will become an even more important input. It is not possible to assess the contribution improved varieties will make in expanding world food output during the remainder of this century. This contribution will depend upon many things such as the particular crop in question, present level of yields, area of production, and extent of adoption by farmers.

Modern knowledge of plant breeding is making possible the gradual expansion of the producing area of the major grains into areas previously used only for grazing or for other less-intensive

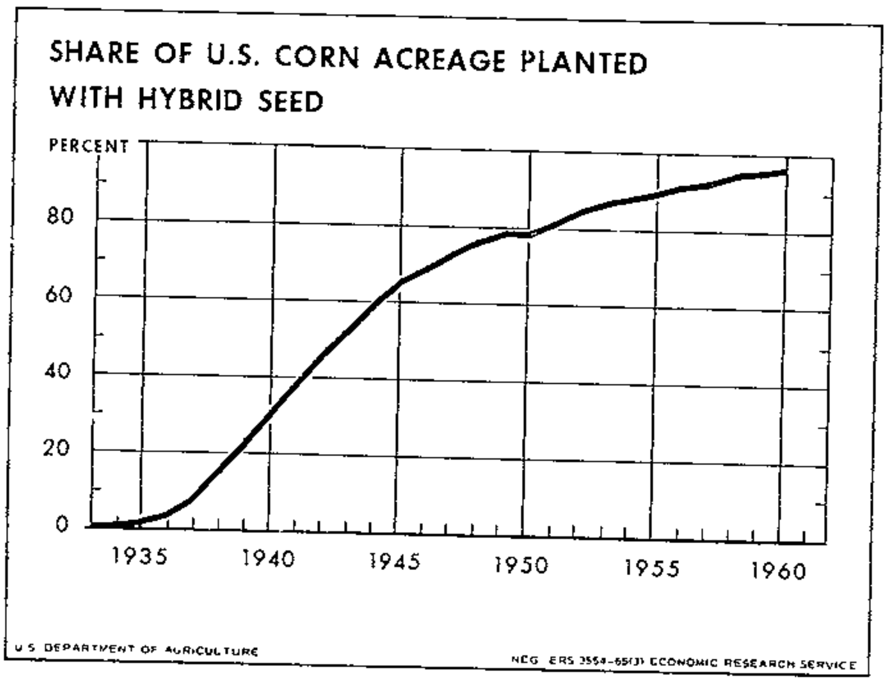

Figure 25

cultivation. Rice production has moved northward in Japan, new drought-resistant varieties have moved wheat production far inland in Australia; the area of corn production (for grain) is gradually moving northward in Europe as new specially selected varieties become available.

Unlike most capital inputs, improved varieties cannot always be imported. They must often be developed indigenously. Seeds introduced from other countries may not be adapted to differences in day length, the growing season may be too short, they may lack resistance to local diseases or insects, or they may not be adapted to local soils. Much time is usually required to develop improved varieties. And yet other capital inputs may not be very effective without improved varieties that are adapted to local growing conditions.

Mechanization

Mechanization may be designed to increase output per person, output per acre, or both. Most often it is designed to increase output per person. Until quite recently, the pattern of mechanization in Western agriculture was directed almost entirely toward increasing output per person. It was labor-saving.

The pattern of agricultural mechanization in Japan, the most advanced agricultural economy in Asia, however, has been oriented much more towards raising yields. Overall capital expenditures by farmers are weighted much more heavily toward raising yields than they are in Western agriculture, where land is much more abundant.

Farm machines can contribute to higher yields in many ways. Because of greater speed and capacity, they may permit better timing of the various tilling, planting, or harvesting operations. Farmers are better able to take advantage of favorable weather conditions.

Many tillage operations are not possible without tractors. Deep-plowing, which can increase yields under certain conditions, is not possible with only a team of bullocks and a wood plow. Subsoiling (to turn, break up, or stir subsoil) will improve drainage under certain conditions, but it requires heavy equipment.

Many of today's most effective pesticides cannot be applied except with high-pressure sprayers. Modern mechanical planters with fertilizer placement attachments do a much better job of seeding and fertilizing than traditional hand methods.

Pawley, (72, p. 115) in discussing possibilities for mechanization in less-developed countries, says:

"... it is necessary to assign a much more modern place to mechanization, since the chief function of machinery is to make it possible for each man to do more work, not to make each hectare grow more food. Nevertheless, improvements in equipment, including animal-drawn implements and hand tools, as well as tractors and tractor-drawn machinery, can make a very appreciable contribution to raising crop yields per hectare, firstly, by enabling various operations to be performed better, and secondly, by making possible more timely operations. Such improvements may also make it possible to farm land that could not be farmed at all with more primitive implements."

One of the principal obstacles to the use of yield-increasing farm machinery, especially of the type developed in the West, is the small size of farms so prevalent throughout the less-developed regions. New methods of ownership and financing of this type of machinery will be needed. Government-supplied credit for purchase by individual farmers who would then do custom work for other farmers in the community would be one possible solution. Machines specifically designed for small farm units are needed as in Japan, where a major step has already been taken in this direction.

Other Yield-Raising Cultural Practices

An almost endless list of yield-raising practices not already discussed could be compiled. The purpose of this section is not to list these practices but rather to draw attention to their existence.

Relatively little attention has been given to using additional labor inputs to raise yields. But in some countries, especially rice-growing countries, the opportunities for raising yields by using more labor inputs are sometimes quite good.

Japan provides some indication of possibilities in this direction. And where yields are extremely low and capital is scarce, increased use of labor may be the easiest way to raise yields over the next few years. Labor inputs per acre are several times higher in Japan than in many other Asian rice-producing countries. The Japanese paddy method of growing rice, provides a means whereby additional labor inputs can be used to raise rice yields. Additional labor inputs can be used both to construct additional water control facilities and to adopt more elaborate, more intensive cultural practices.

The Japanese paddy method has several advantages over the traditional, broadcast method. Weed control is more efficient and less costly, less seed is wasted, the field-growing season is shortened, the irrigation period is shortened, and water requirements are lessened. The shortening of the field-growing season permits double-cropping in many areas where this would not otherwise be possible. This method of cultivation does, however, require more fertilizer and a dependable source of irrigation water, along with the much greater use of labor.

Chapter X.--POTENTIAL AND PROSPECTS FOR INCREASING YIELDS

Potential For Increasing Yields

In discussing the potential for increasing yields per acre, it is useful to distinguish between the technical potential and the economic potential. The technical potential for increasing yields is defined within the context of this study as the physically or technically possible yield level with little regard for cost-price relationships. The economic potential for raising yields refers to yield levels which are economically feasible--i.e., profitable--with a given technology.

The Technical Potential

The concept of the technical potential for raising yields has limited practical application, since production decisions are made almost entirely on the basis of economic relationships. The concept is useful, however, in providing insight into future yield possibilities.

Many known yield-raising techniques, not at present economically practical, will one day be profitable. Technology is always changing, at least in the developed countries, and with these changes some changes in the economic potential for raising yields. To illustrate, irrigation with sea water, now too costly to be profitable, may one day become profitable if the current downward trend in the cost of desalting sea water continues. Numerous examples could be cited of yield-raising techniques now widely used, which were too costly to be practical when first developed.

The level of yields technically attainable is much higher than the level of yields economically feasible. No effort will be made to determine, in quantitative terms, the technical potential for raising yields.

The range between the highest and lowest national average yields in 1962 among major producing countries was 4 to 1 for rice, 8 to 1 for wheat, and 6 to 1 for corn. And yet even the highest average national yields are far below the technical potential for raising yields. Corn yields in the 4 leading corn-pr[illegible]cing states in the

United States--Indiana, Illinois, Iowa, and Ohio--averaged between 80 and 85 bushels per acre in 1963. Individual farmers have attained yields ranging up to 150 bushels, and more, per acre on large acreages. These yields have been attained not because of any uncommon inherent fertility of soils on these farms but rather because individual farmers have succeeded in putting together a highly successful combination of yield-raising techniques.

H. L. Richardson notes that in Japan some villages obtain an average of 11,000 pounds of paddy rice per acre (76, p. 19). This is nearly two-and-one-half times the high national average rice yield of Japan.

Present yield-raising techniques would permit average world yields to be increased at least a few-fold and perhaps much more. Present limitations on world food output derive not so much from a lack of technological know-how as from inability to apply the existing know-how for social, economic, or other reasons.

The Economic Potential

The economic potential for raising yields is always somewhat less than the technical potential. Many yield-raising techniques, demonstrated in experimental plots, are too costly to be used commercially. This section deals with what determines whether a given yield-raising technique is economical.

The potential for greatly increasing yields is very much dependent on the level of capital inputs. Several economic factors influence the extent to which capital inputs are used. Most of these factors affect the farmer's cost-price relationships.

The economic potential for raising yields is often lower in underdeveloped economies than in the more advanced economies because the cost of capital inputs is much higher. Many of the yield-raising capital inputs such as the agricultural chemicals--fertilizer, insecticides, fungicides, and herbicides--are not produced in the underdeveloped economies. The combined effect of international transport costs and inefficient indigenous distribution systems pushes the cost of capital inputs to farmers well above those in the advanced countries.

Another factor limiting the economic potential for raising yields in underdeveloped economies is the lack of capital in rural areas to finance yield-raising capital inputs. Where incomes are low, capital for investment in agriculture is usually in short supply; after the purchase of food, clothing, housing, fuel, and other necessities, little is left for the purchase of capital inputs. And even where capital is available, interest rates are high. Thus, even where farmers are convinced of the worth of certain capital inputs, they may not have the capital to finance them.

Insofar as capital inputs must be imported, another possible factor--the availability of foreign exchange--may limit their use. Yield-raising capital inputs for agriculture must compete with other urgent needs for the allocation of scarce foreign exchange.

In summary, at least 3 economic factors dealing with the cost of inputs serve to reduce the use of capital inputs, and therefore the economic yield potential, in underdeveloped countries below that of the developed countries. These are the lack of capital to finance capital inputs and, when capital inputs must be imported, the additional transport and distribution costs, and the scarcity of foreign exchange.

Prices of farm products also influence the level of capital inputs per acre. Where prices are high, farmers can move further up the cost curve, which tends to rise as farmers attempt to extract more and more output from a fixed area of land. Yield-raising inputs which are marginal at a given food price level might become profitable if food prices were higher. Other things being equal, countries which can afford higher prices can attain higher per acre yields.

Prices of rice and yields of rice are both far higher in Japan than in any other country in Asia. If prices of rice were to drop to Indian levels, for instance, yields in Japan would in all probability decline as farmers cut back the use of some of the less-effective capital inputs.

Countries with low per capita incomes cannot, in general, afford high food prices. These countries thus have less yield-raising potential than those with higher incomes. Rice prices in Japan are some 3 times those in India. If rice were as costly to Indians, who spend nearly half of their total income on food (at Indian prices), as to the Japanese, virtually their entire income would be required to purchase food alone.

It is necessary to understand the economic limitations on raising yields discussed above if an accurate assessment of the prospects for raising yields, particularly in less-developed countries, is to be made. It will be some time before less-developed countries such as India, Pakistan, or Mainland China will be able to afford yields comparable to those now existing in Japan. Too often the yield level attained in a developed country is assumed to be readily within the reach of a less-developed country. But this is not a realistic assumption, because the economic environments of the 2 countries are invariably quite different.

Because per acre grain yields in Japan are 3 times those in India, it is commonly assumed that yields in India can readily be tripled.[1] This is an example of the misuse of yield comparisons between countries at quite different stages of development. First, as already mentioned, per capita incomes in India are not high enough to sustain food prices at the levels prevailing in Japan. Second, assuming that the response of grain to fertilizer were the same in India as in Japan, India would require, to triple yields, more fertilizer than the world currently produces--and more than India could afford. And this does not include the financing of the complementary inputs needed if the fertilizer were to be used effectively.

India cannot now, or in the foreseeable future, produce even a sizable fraction of the quantities of fertilizer needed to triple yields. Most would have to be imported. And the foreign exchange required for such imports is not now available. These few considerations completely ignore other important factors such as the ability of villagers to use chemical fertilizers and the investment required to develop an adequate distribution system.

Many other examples of unwarranted comparisons could be cited. The fact that the United States has average national corn yields 6 times greater than those of the Philippines does not mean that yields in the Philippines can be increased sixfold either now or in the foreseeable future. The basic economic relationships within the 2 economies are vastly different. The technical potential for reaching U.S. corn yield levels in the Philippines may be good, but the economic potential is not, at the present stage of development.

In summary, the failure to distinguish between the technical potential for raising yields and the economic potential for raising yields has resulted in unrealistic estimates of the prospects for raising yields, particularly in the less-developed countries. The technical potential for raising yields is sufficiently great that it will not impose any serious limitations on increasing world food output in the foreseeable future. The economic potential for raising yields, however, is much less, and will impose serious limitations on efforts to expand food output in the less-developed regions at a rate commensurate with the rate of population growth.

Prospects for Increasing Yields

In many less-developed countries, the supply of new land that can readily be brought under cultivation is nearly exhausted. This requires changes in attitude on the part of government leaders and

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[1] Tripling grain yields in India would bring per capita grain supplies for the present population up to nearly two-thirds those of the United States.

economic planners. When it was still possible to increase food output by simply expanding the area under cultivation, agriculture required relatively little attention. But as it becomes possible to increase food output only by raising yields, an immeasurably greater effort is required. And both government and farmers must be prepared to make this greater effort.

Near-Term Prospects

The near-term prospects for raising yields vary widely among countries. In some countries, yields will rise very rapidly; in others they will rise, but at very modest rates. In still others, they will, in all likelihood, decline, continuing the downward trends in evidence over the last 25 years.

Those countries which have experienced yield takeoffs will continue to raise yields very rapidly, perhaps even more rapidly than in recent years. The more advanced countries which have achieved yield takeoffs, such as the United States, Canada, France, West Germany, and the United Kingdom, will probably continue to raise yields at close to 2 percent per year. Some countries could conceivably do much better. Another group of countries in the intermediate stages of development, which have either recently experienced yield takeoffs or appear about to achieve yield takeoffs, will probably raise yields at an average rate of 1 to 2 percent per year. Italy, Spain, Yugoslavia, and China (Taiwan) might be in this group.

A large number of countries in Asia, Africa, and Latin America will find it very difficult to raise yields as much as 1 percent per year over a sustained period. Included in this group are India, Mainland China, Pakistan, Indonesia, Egypt, Iraq, and many more--countries containing two-thirds of the world's people.

Nearly all the major rice-producing countries of Asia are in this category. These countries have raised yields over the past 25 years, but at very modest rates. Except for Japan, the rate of increase in every case was below 1 percent per year. And many of the yield increases were due to the rising labor inputs associated with a rapidly growing population. After a point, additional labor inputs have little effect on yields unless capital inputs are forthcoming.

Perhaps the most significant aspect of the rankings (table 25) was the tendency for entries of different grains for the same country to be quite close together. This indicates that factors other than those pertaining to the particular crop were the principal determinants of the rate of yield increase. The United States and Brazil, for instance, both qualified as major producers of all 3

Table 25.--Ranking and annual rates of change in yield per acre of rice, wheat, and corn and annual rates of population growth, major grain-producing countries[1]

Country	Crop	Annual compound rate of change in yields 1935-39 to 1960-62 (col. a)	Annual compound rate of population increase in recent years[2] (col. b)	Rate of population growth subtracted from rate of yield increase (col. a - col. b)
Rank		Percent	Percent	Percent
1 United States	corn	3.7	1.7	+2.0
2 Mexico	wheat	3.3	3.1	+0.2
3 United States	wheat	2.7	1.7	+1.0
4 Canada	wheat	2.3	2.2	+0.1
5 France	wheat	2.3	1.0	+1.3
6 Canada	corn	2.2	2.2	0
7 Portugal	corn	2.1	0.8	+1.3
8 France	corn	2.0	1.0	+1.0
9 Greece	wheat	2.0	0.9	+1.1
10 United Kingdom	wheat	2.0	0.7	+1.3
11 United States	rice	1.9	1.7	+0.2
12 Mexico	corn	1.8	3.1	-1.3
13 Italy	corn	1.7	0.5	+1.2
14 Soviet Union	corn	1.6	1.7	-0.1
15 Australia	wheat	1.5	2.2	-0.7
16 Germany (West)	wheat	1.5	1.2	+0.3
17 Rumania	corn	1.4	0.9	+0.5
18 Morocco	wheat	1.3	2.8	-1.5
19 Bulgaria	corn	1.2	0.9	+0.3
20 Yugoslavia	wheat	1.2	1.1	+0.1
21 South Africa	corn	1.1	2.6	-1.5
22 Spain	corn	1.1	1.0	+0.1
23 Argentina	wheat	1.0	1.7	-0.7
24 Japan	rice	1.0	0.9	+0.1
25 China (Taiwan)	rice	0.9	3.7	-2.8
26 Yugoslavia	corn	0.9	1.1	-0.2
27 Chile	wheat	0.8	2.4	-1.6
28 Italy	wheat	0.8	0.5	+0.3
29 South Africa	wheat	0.8	2.6	-1.8
30 U.A.R. (Egypt)	rice	0.8	2.5	-1.7
31 Algeria	wheat	0.7	1.9	-1.2
32 Colombia	corn	0.7	2.2	-1.5
33 Hungary	wheat	0.7	0.5	+0.2
34 India	rice	0.7	2.2	-1.5
35 Korea (South)	rice	0.7	2.9	-2.2
36 Poland	wheat	0.7	1.4	-0.7
37 Burma	rice	0.6	2.1	-1.5
38 India	wheat	0.6	2.2	-1.6
39 Rumania	wheat	0.6	0.9	-0.3
40 Brazil	rice	0.5	3.1	-2.6
41 India	corn	0.5	2.2	-1.7
42 Indonesia	rice	0.5	2.3	-1.8
43 Pakistan	corn	0.5	2.1	-1.6
44 Pakistan	wheat	0.5	2.1	-1.6
45 Hungary	corn	0.4	0.5	-0.1
46 Argentina	corn	0.3	1.7	-1.4
47 Philippines	rice	0.3	3.3	-3.0
48 Spain	wheat	0.2	1.0	-0.8
49 Bulgaria	wheat	0.1	0.9	-0.8
50 Turkey	wheat	0.1	2.9	-2.8
51 Iraq	wheat	0	3.3	-3.3
52 Philippines	corn	0	3.3	-3.3
53 Soviet Union	wheat	0	1.7	-1.7
54 Brazil	corn	-0.1	3.1	-3.2
55 Brazil	wheat	-0.1	3.1	-3.2
56 Indonesia	corn	-0.2	2.3	-2.5
57 Malagasy Republic	rice	-0.2	2.8	-3.0
58 Thailand	rice	-0.3	3.0	-3.3
59 Congo (Leopoldville)	corn	-0.5	2.4	-2.9
60 U.A.R. (Egypt)	corn	-0.7	2.5	-3.2
61 Turkey	corn	-0.8	2.9	-3.7
62 Guatemala	corn	-1.0	3.1	-4.1
63 Tunisia	wheat	-1.1	1.7	-2.8

[1] In the past there has not been any direct relationship between rate of yield per acre increase and rate of population growth in many countries. But as more and more countries become "fixed-land" economies, yields will have to increase as rapidly as population to avoid a declining trend of food output per person.

[2] These are rates for the most recent period for which data are available, in most cases the 5-year period from 1958 to 1962.

grains. Among the 63 entries, the 3 U.S. entries ranked 1, 3, and 11. The 3 Brazilian entries were 40, 54, and 55.

Several countries qualified as major producers of 2 of the 3 grains. Many of these countries achieved similar rates of gain for both grains. Out of the 63 entries, Canada was 4 and 6, France 5 and 8, Mexico 2 and 12, Yugoslavia 20 and 26, India 38 and 41, Pakistan 43 and 44, and the Philippines 47 and 52. A few countries had widely disparate rates of increase. Egypt ranked 30 and 60; Bulgaria, 19 and 49.

Also demonstrating the close relationship between the level of development and the capacity to raise yields was the tendency for the most advanced countries to be clustered at the top and the least-advanced countries to be grouped at the bottom. All of the top 13 countries were in either North America or Western Europe with the exception of Mexico. All of the countries in the lower half of the rankings were the less-developed countries of Asia, Africa, and Latin America, except for a few East European countries such as Bulgaria, and the Soviet Union.

In a small number of countries which are major producers of rice, wheat, or corn, yields have actually trended downward over the past 25 years. Brazil, Thailand, Turkey, Guatemala, and Tunisia are in this group. The causes of these downward trends vary somewhat among countries.

Thailand, unable to raise rice yields to meet the food needs of its growing population, nearly doubled the area in rice between 1935-39 and 1960-62. Much of the land added was of less-than-average quality both in terms of inherent fertility and availability of water. Some of the other countries with declining yield trends also expanded production onto marginal land.

Several countries with declining yields were densely populated corn-producing countries where the opportunities for rotating corn with other crops, often producing fewer calories per acre, were limited. Continuous cropping of corn has resulted in soil-depletion problems, avoided in some of the more advanced countries possessing a more advanced agricultural technology. Yields may continue to decline in some of these countries over the next few years. The conditions causing the decline in yields are still present; the technical know-how and the financial wherewithal required to arrest and reverse these trends do not yet exist.

Long-Term Prospects

Long-term prospects for raising yields are much brighter than the near-term prospects because the time required to develop many of the conditions favorable for a yield takeoff is not available in the short term. Time is required for a largely illiterate society to become literate. A decade hence, many societies now largely illiterate may be largely literate.

Low-income countries able to attain economic growth rates in excess of their population growth rates will have higher per capita incomes. This should increase the supply of capital available for investment in yield-raising inputs and thereby enhance the prospects for a yield takeoff.

With time, agriculture will become more market-oriented, thus giving farmers more opportunities to purchase yield-raising capital inputs. As industry develops, many yield-raising capital inputs, now imported, should become available indigenously. This should lower costs and reduce the restricting effect of foreign exchange shortages on the use of capital inputs.

Chapter XI.--PROSPECTIVE TRENDS IN PER CAPITA FOOD OUTPUT

Prospective Trends in Developed Regions

The rate of increase in yields of the leading grains in the major grain-producing countries of North America and Western Europe exceeds that of population in every case. Population in the United States has been increasing at the rate of 1.7 percent per year. Yields of corn, wheat, and rice have been rising 3.7, 2.7, and 1.9 percent per year, respectively, since prewar. Per capita output of all 3 grains has trended upward. France has increased wheat yields 2.3 percent per year--more than twice as fast as population, increasing only 1 percent per year. Wheat yields in the United Kingdom have risen more than twice as fast as population. Italy has increased corn yields 1.7 percent per year and wheat yields 0.8 percent per year, but population is increasing only 0.5 percent per year. Wheat yields have increased slightly faster than population in both Canada and West Germany.

Annual rates of yield increase and annual rates of population growth are not too different in most East European countries. Per capita output of wheat and corn has increased slightly in some countries and declined slightly in others. Population growth rates have generally been low, ranging below 1 percent in Bulgaria, Czechoslovakia, and Hungary and being negative in East Germany.

The Soviet Union has had no success in raising yields of wheat, the principal grain and national food staple. Until quite recently, efforts at increasing wheat output were directed towards expanding the cultivated area, often into marginal rainfall areas. Eastern Europe and the Soviet Union seem to have most of the factors needed for a yield takeoff, but incentives and the link between effort and reward remain weak.

Wheat yields in Australia, increasing at 1.5 percent per year since 1935-39, have lagged slightly behind population growth, which has been stimulated by a steady influx of immigrants. Vast expansions in the wheat-producing area, however, have resulted in pronounced gains in wheat output per person.

In North America, Western Europe, and Oceania (Australia and New Zealand), where nearly all countries have achieved yield takeoffs, per capita output of the principal grains is likely to increase even faster than in recent years. In North America and Australia, most if not all the increase in per capita grain output will be channeled into exports. Increases in Western Europe will be absorbed in large part by the growing livestock industry, which is expanding rapidly in response to the rising per capita consumption of livestock products. These anticipated gains in per capita grain output in Western Europe may result in reduced dependence on imports in some individual countries. Any gains in per capita grain output in Eastern Europe and the Soviet Union will probably also be absorbed by the growing numbers of livestock.

Prospective Trends in Less-Developed Regions

During the 1950's, per capita food output in the less-developed regions trended upward, generally reaching the levels achieved prior to World War II. But in the 1960's, per capita output has been declining. Food output per person in Asia, excluding Mainland China, has declined 4 percent from the postwar high reached in 1961. Food output per person in Mainland China has been declining since 1958. In Latin America, per capita food output has declined 6 percent from the postwar high reached in 1958.

Africa alone among the less-developed regions has avoided a downward trend in per capita food output. If population growth continues to accelerate as death rates are further reduced, Africa, too, may be faced with declining food output per person. It is not surprising that these regions are losing the race with population. The agricultural sectors of even the most advanced countries would be hard-pressed to maintain rates of increase in food output equal to current rates of population growth in Latin America and Asia.

Additions to the food supplies of the United States and Western Europe over the past 25 years have occurred entirely as a result of raising yields, since the area in crops is now less than during pre-World-War-II years. France increased wheat yields 2.3 percent per year during this period. With population growing at 1 percent per year, output per person climbed steadily. But if France's population growth had been 3.1 percent as in Brazil, per capita output would have declined 1.3 percent per year.

Japan's rice yields have increased an average of 1 percent per year since 1935-39, but population is gaining at less than 1 percent per year. If Japan had experienced a population growth rate of 2.2 percent per year, as India is now experiencing, per capita rice output would have dropped drastically over the last 25 years.

The United States, one of the most successful countries in raising yields, increased wheat yields at 2.7 percent per year. With the population growth rate of Guatemala (3.1 percent per year) or the Philippines (3.3. percent per year), this rate of increase in wheat output would not have been sufficient to avoid a downturn in per capita wheat output.

Given the projected high population growth rates of nearly all countries in Asia, Africa, and Latin America, the limited possibilities for expanding the cultivated area in most of the densely populated countries, and the lack of success in generating a yield takeoff, it does not appear likely that the downward trends in per capita food output now in evidence in these regions can be easily arrested. Barring a rise in the death rate due to widespread malnutrition in these regions, projections show the fastest population increase in history over the next 10 years. Failure to arrest the downward trend in per capita food output in these regions will leave two alternatives: (1) a continuing decline in consumption levels (narrowing the already thin margin between current consumption levels and survival levels); or (2) growing dependence on food imports--if imports are available.

Chapter XII.--CONCLUSIONS

The prospects for increasing food output per person contrast sharply between the developed and less-developed regions. The principal conclusions concerning the prospects for increasing food output are therefore presented separately for the 2 regions.

(1) Food output per person will probably continue to trend steadily upward in North America, Western Europe, and Oceania. In Eastern Europe (including the Soviet Union), it will probably also trend upward but at a more modest rate. Further increases in North America and Oceania will be channeled largely into exports. Increases in Western Europe and Eastern Europe will likely be absorbed domestically.

(2) The prospects for many of the less-developed countries are not good. Lacking both new land to bring under cultivation and a significant yield-raising capability, many of these countries will find it difficult to arrest the downward trend in per capita food output in evidence over the past few years.

The following conclusions support the major conclusions stated above.

(1) The land-man relationships existing in the less-developed countries are far less favorable to economic development than those that existed in the now-advanced countries when they initiated their development. Cropland per person, only a fraction of what it was in the advanced economies at a comparable stage in their development, is declining rapidly. Population growth is much more rapid than it was in the advanced economies when they initiated their development or, for that matter, at any time in their history. And opportunities for large scale emigration from overpopulated areas to relieve population pressure no longer exist.

(2) The less-developed countries face 2 severe handicaps as they attempt to make the transition from the area-expanding method of increasing food output to the yield-raising method.

They have very little time in which to make the transition, and they must do it while still in the very early stages of development.

(3) Several advanced countries have generated and sustained a trend of rapidly rising yields. The experiences of these countries show that certain basic factors are almost always associated with a "yield takeoff." These are a relatively high level of literacy, per capita income levels far enough above subsistence levels to provide capital for investment in yield-raising capital inputs, a high degree of market orientation in agriculture, and development of the nonagricultural sector to the point where it can supply farmers with the goods and services required to raise yields in a rapid, sustained fashion.

(4) The ability to raise yields per acre is closely associated with the level of development.

(5) The less-developed, fixed-land countries must substantially improve upon the yield-raising performances of the developed countries if they are to succeed in feeding their populations.

(6) The yield gap between the developed and less-developed countries, like the income gap, is steadily widening. The ratio between rice yields in the major rice-producing countries with the highest and lowest acreage yields increased from 3 to 1 during the 1935-39 period to 4 to 1 in the early 1960's. For wheat, the yield gap widened even more dramatically, going from 5 to 1 prewar to 10 to 1 in recent years. And for corn, the third major grain, the ratio of 4 to 1 increased to 6 to 1.

(7) Increases in food output per person, in essentially fixed-land economies, are directly dependent on increases in food output per acre. The failure to raise yields at least as fast as population, results in declining output per person.

(8) There is no assurance that once a country has exhausted the supply of readily cultivable land that it can generate a yield-per-acre takeoff.

(9) The rapid growth in the need for professional agricultural workers, especially those needed to do adaptive research in

the less-developed regions, may result in a worldwide shortage in the near future.

(10) Food shortages emerging in the less-developed world are not due to a lack of technology but to the inability to apply existing technology as fast as current and projected rates of population growth require.

(11) Food shortages characterizing so many less-developed economies are a symptom of a much broader problem--the unprecedented rates of population growth now prevailing in almost every less-developed country. Other symptoms are housing shortages, lack of school facilities and rising numbers of unemployed.

(12) The food shortages, increasingly in evidence in some of the large, densely populated countries such as India, Mainland China, and Indonesia threaten to become chronic unless an immediate and dramatic effort to increase food output is forthcoming.

(13) The less-developed countries, lacking the time which the now-advanced countries had to improve their agriculture, will be forced to look to the advanced countries for much more technical assistance than at present.

(14) It will be very difficult to establish a secure and lasting world order in a situation where the less-developed world continues to become increasingly dependent on concessional food shipments from the advanced countries.

(15) The solution to the food problem of the less-developed countries must come from improving the agriculture within these countries. Food shipments from the developed countries can help but they cannot account for more than a very small fraction of projected increases in food needs over the next several years.

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APPENDIX

Table 26.--Australia--all grains combined: Area, production and yield per acre, 1860-1963[1]

Year[2]	Area[3]	Production	Yield per acre[4]	Year[2]	Area[3]	Production	Yield per acre[4]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1860...	852	397	466	1922...	11,433	3,588	314
1865...	1,115	405	363	1923...	11,192	4,035	361
1870...	1,508	478	317	1924...	12,649	5,262	416
1875...	1,824	722	396	1925...	11,886	3,671	309
1880...	3,510	885	252	1926...	13,189	4,937	374
1885...	3,567	794	223	1927...	14,124	3,837	272
1886...	3,961	1,089	275	1928...	16,556	4,963	300
1887...	4,224	1,346	319	1929...	17,242	4,089	237
1888...	3,824	770	201	1930...	19,923	6,470	325
1889...	4,253	1,307	307	1931...	16,437	5,786	352
1890...	3,918	1,110	283	1932...	17,464	6,441	369
1891...	3,933	1,065	271	1933...	17,044	5,504	323
1892...	4,010	1,223	305	1934...	14,857	4,325	291
1893...	4,609	1,397	303	1935...	14,384	4,673	325
1894...	4,508	1,160	257	1936...	14,630	4,772	326
1895...	4,295	815	190	1937...	16,088	5,864	364
1896...	5,255	993	189	1938...	17,199	4,935	287
1897...	5,145	1,172	228	1939...	16,115	6,708	416
1898...	6,231	1,544	248	1940...	15,488	2,819	182
1899...	6,441	1,503	233	1941...	14,548	5,539	381
1900...	6,579	1,814	276	1942...	11,513	4,992	434
1901...	5,947	1,440	242	1943...	10,016	3,668	366
1902...	6,127	618	101	1944...	11,368	1,880	165
1903...	6,680	2,643	396	1945...	14,309	4,742	331
1904...	7,200	1,896	263	1946...	15,916	3,884	244
1905...	6,996	2,310	330	1947...	17,047	7,359	432
1906...	6,996	2,364	338	1948...	15,547	6,153	396
1907...	6,458	1,634	253	1949...	15,222	7,031	462
1908...	6,402	2,283	357	1950...	14,668	6,109	416
1909...	7,792	3,057	392	1951...	14,037	5,572	397
1910...	8,572	3,250	379	1952...	14,524	7,025	484
1911...	8,501	2,397	282	1953...	14,870	7,051	474
1912...	8,710	3,095	355	1954...	15,108	5,981	396
1913...	10,701	3,410	319	1955...	15,581	7,410	476
1914...	10,920	1,001	92	1956...	12,705	5,559	438
1915...	13,701	5,432	396	1957...	14,112	4,059	288
1916...	12,967	4,712	363	1958...	16,934	9,031	533
1917...	10,928	3,627	332	1959...	17,766	7,198	405
1918...	9,300	2,532	272	1960...	20,091	10,531	524
1919...	8,019	1,748	218	1961...	19,481	8,854	454
1920...	10,628	4,652	438	1962...	21,662	10,679	493
1921...	11,056	4,070	368	1963...	21,327	11,190	525

[1] Includes wheat, barley, oats, and corn.
[2] Calendar year notation refers to crop year: 1963 = 1963/64.
[3] Area sown.
[4] Calculations based on unrounded figures.

Source: (5).

Table 27.--Australia--wheat: Area, production and yield per acre, 1860-1963

Year[1]	Area[2]	Production	Yield per acre[3]	Year[1]	Area[2]	Production	Yield per acre[3]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1860...	644	279	433	1922...	9,764	2,979	305
1865...	818	263	322	1923...	9,540	3,402	357
1870...	1,124	329	293	1924...	10,825	4,479	414
1875...	1,422	509	358	1925...	10,201	3,116	305
1880...	3,053	636	208	1926...	11,688	4,375	374
1885...	2,980	489	164	1927...	12,279	3,217	262
1886...	3,422	810	237	1928...	14,840	4,346	293
1887...	3,648	1,039	285	1929...	14,977	3,453	231
1888...	3,199	474	148	1930...	18,165	5,813	320
1889...	3,534	926	262	1931...	14,741	5,188	352
1890...	3,229	738	229	1932...	15,766	5,822	369
1891...	3,335	699	210	1933...	14,901	4,826	324
1892...	3,441	892	259	1934...	12,544	3,630	289
1893...	3,922	1,011	258	1935...	11,957	3,925	328
1894...	3,700	758	205	1936...	12,317	4,120	334
1895...	3,521	497	141	1937...	13,735	5,096	371
1896...	4,280	568	133	1938...	14,346	4,228	295
1897...	4,356	769	177	1939...	13,285	5,728	431
1898...	5,469	1,127	206	1940...	12,645	2,238	177
1899...	5,614	1,088	194	1941...	12,003	4,537	378
1900...	5,667	1,316	232	1942...	9,280	4,238	457
1901...	5,116	1,049	205	1943...	7,875	2,986	379
1902...	5,156	337	65	1944...	8,463	1,439	170
1903...	5,566	2,018	363	1945...	11,425	3,876	339
1904...	6,270	1,484	237	1946...	13,180	3,191	242
1905...	6,123	1,865	305	1947...	13,880	5,991	432
1906...	5,982	1,808	302	1948...	12,583	5,190	412
1907...	5,384	1,215	226	1949...	12,240	5,939	485
1908...	5,262	1,703	324	1950...	11,663	5,014	430
1909...	6,586	2,461	374	1951...	10,384	4,347	419
1910...	7,372	2,589	351	1952...	10,209	5,313	520
1911...	7,428	1,950	263	1953...	10,751	5,388	501
1912...	7,340	2,503	341	1954...	10,673	4,589	430
1913...	9,287	2,812	303	1955...	10,166	5,319	523
1914...	9,651	677	70	1956...	7,874	3,659	465
1915...	12,485	4,873	390	1957...	8,848	2,655	300
1916...	11,533	4,148	360	1958...	10,399	5,855	563
1917...	9,775	3,123	319	1959...	12,172	5,402	444
1918...	7,990	2,059	258	1960...	13,439	7,449	554
1919...	6,419	1,251	195	1961...	14,700	6,728	458
1920...	9,072	3,970	438	1962...	16,500	8,352	506
1921...	9,719	3,513	361	1963...	16,300	8,818	541

[1] Calendar year notation refers to crop year, i.e. 1963 = 1963/64. [2] Area sown.
[3] Calculations based on unrounded figures.

Source: (5).

Table 28.--India: Yield per acre of individual grains and average for all grains, 1896-1963

[Kilograms per acre]

Year	Rice[1]	Wheat	Jowar	Bajra	Corn	Barley	Ragi	All grains combined[2]
1896-1900.....	286	270	--	--	--	--	--	281
1901-1905.....	291	306	--	--	--	--	--	296
1906-1910.....	269	309	--	--	--	--	--	282
1911-1915.....	273	321	--	--	--	--	--	288
1916-1920.....	272	309	--	--	--	--	--	283
1921-1925.....	258	310	--	--	--	--	--	272
1926-1930.....	254	287	--	--	--	--	--	263
1931-1935.....	253	277	--	--	--	--	--	263
1936-39.......	367	283	198	159	310	242	316	286
1940..........	349	306	202	145	342	342	314	283
1941..........	316	284	217	178	350	369	357	277
1942..........	334	274	187	167	322	318	337	269
1943..........	339	293	186	177	341	335	319	273
1944..........	367	274	191	178	338	318	320	284
1945..........	342	276	172	142	302	362	316	263
1946..........	327	248	146	126	281	323	242	242
1947..........	340	202	142	128	275	348	290	244
1948..........	335	272	167	137	290	354	287	261
1949..........	317	257	138	112	250	291	278	242
1950..........	312	265	153	124	254	286	283	244
1951..........	270	269	143	117	221	309	263	224
1952..........	289	264	154	100	254	303	243	230
1953..........	309	309	170	120	322	365	241	252
1954..........	365	304	184	151	318	338	325	281
1955..........	332	325	213	125	321	353	291	275
1956..........	354	287	157	122	285	333	324	265
1957..........	364	281	183	103	332	329	318	275
1958..........	318	269	199	132	314	301	295	259
1959..........	379	319	208	137	328	329	308	296
1960..........	367	314	191	132	351	322	304	288
1961..........	408	342	219	113	370	351	289	305
1962..........	382	355	209	137	375	377	310	302
1963	393	348	216	143	391	375	317	307

[1] In terms of milled rice.
[2] Weighted average.

Source: (50).

Table 29.--Japan--all grains combined: Area, production and yield per acre, 1878-1963[1]

Year	Area	Production	Yield per acre[2]	Year	Area	Production	Yield per acre[2]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1878...	8,905	4,258	478	1921...	11,853	10,048	848
1879...	9,119	5,087	558	1922...	11,646	10,794	927
1880...	9,229	5,341	579	1923...	11,436	9,717	850
1881...	9,212	4,950	537	1924...	11,285	9,994	886
1882...	9,356	5,266	563	1925...	11,321	10,806	955
1883...	9,408	5,203	553	1926...	11,296	10,154	899
1884...	9,380	4,860	518	1927...	11,258	10,924	970
1885...	10,163	6,024	593	1928...	11,241	10,704	952
1886...	10,304	6,934	673	1929...	11,252	10,572	940
1887...	10,361	7,297	704	1930...	11,237	11,354	1,010
1888...	10,557	7,045	667	1931...	11,264	10,166	903
1889...	10,741	6,285	585	1932...	11,311	10,914	965
1890...	10,904	7,057	647	1933...	11,184	12,318	1,101
1891...	10,954	7,322	668	1934...	11,192	10,000	893
1892...	11,009	7,508	682	1935...	11,368	10,917	960
1893...	11,062	7,028	635	1936...	11,432	11,971	1,047
1894...	10,982	8,039	732	1937...	11,493	12,047	1,048
1895...	11,152	7,745	694	1938...	11,534	11,668	1,012
1896...	11,153	6,968	625	1939...	11,493	12,902	1,123
1897...	11,097	6,619	596	1940...	11,646	11,829	1,016
1898...	11,313	8,857	783	1941...	11,820	10,662	902
1899...	11,363	7,670	675	1942...	12,059	12,204	1,012
1900...	11,317	8,056	712	1943...	11,707	11,037	943
1901...	11,410	8,816	773	1944...	11,645	11,133	956
1902...	11,382	7,200	633	1945...	11,047	8,109	734
1903...	11,407	7,839	687	1946...	10,444	9,927	950
1904...	11,446	9,285	811	1947...	10,587	10,233	967
1905...	11,491	7,398	644	1948...	11,574	12,164	1,051
1906...	11,512	8,676	754	1949...	11,694	11,911	1,019
1907...	11,501	9,266	806	1950...	11,849	12,148	1,025
1908...	11,504	9,579	833	1951...	11,688	11,949	1,022
1909...	11,518	9,666	839	1952...	11,515	12,792	1,111
1910...	11,543	8,758	759	1953...	11,420	11,020	965
1911...	11,586	9,611	830	1954...	11,705	12,455	1,064
1912...	11,681	9,530	816	1955...	12,060	15,232	1,263
1913...	11,880	9,806	825	1956...	12,063	13,634	1,130
1914...	11,875	10,228	861	1957...	11,836	13,922	1,176
1915...	11,855	10,404	878	1958...	11,786	14,262	1,210
1916...	11,878	10,700	901	1959...	11,817	15,100	1,278
1917...	11,813	10,296	872	1960...	11,733	15,559	1,326
1918...	11,808	10,128	858	1961...	11,471	15,145	1,320
1919...	11,821	11,071	937	1962...	11,213	15,285	1,364
1920...	11,931	11,259	944	1963...	10,917	13,252	1,214

[1] Includes rice, wheat and barley.
[2] Calculations based on unrounded figures.

Source: Compiled from tables 30 and 31.

Table 30.--Japan--rice: Area, production and yield per acre, 1878-1963[1]

Year	Area	Production	Yield per acre[2]	Year	Area	Production	Yield per acre[2]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1878...	5,559	3,122	562	1921...	7,665	7,390	964
1879...	5,647	3,896	690	1922...	7,680	8,133	1,059
1880...	5,728	3,858	674	1923...	7,697	7,427	965
1881...	5,706	3,677	644	1924...	7,685	7,660	997
1882...	5,778	3,746	648	1925...	7,713	7,998	1,037
1883...	5,763	3,748	650	1926...	7,725	7,449	964
1884...	5,733	3,292	574	1927...	7,762	8,321	1,072
1885...	6,400	4,566	713	1928...	7,806	8,080	1,035
1886...	6,415	4,988	778	1929...	7,352	7,980	1,016
1887...	6,462	5,364	830	1930...	7,923	8,962	1,131
1888...	6,584	5,183	787	1931...	7,945	7,585	955
1889...	6,681	4,427	663	1932...	7,963	8,293	1,041
1890...	6,733	5,772	857	1933...	7,757	9,729	1,254
1891...	6,756	5,113	757	1934...	7,757	7,115	917
1892...	6,751	5,549	822	1935...	7,832	7,886	1,007
1893...	6,787	4,989	735	1936...	7,837	9,245	1,180
1894...	6,692	5,608	838	1937...	7,861	9,105	1,158
1895...	6,810	5,354	786	1938...	7,870	9,044	1,149
1896...	6,829	4,855	711	1939...	7,801	9,468	1,214
1897...	6,817	4,426	649	1940...	7,764	8,352	1,076
1898...	6,892	6,351	922	1941...	7,775	7,561	972
1899...	6,947	5,319	766	1942...	7,735	9,169	1,185
1900...	6,919	5,557	803	1943...	7,603	8,640	1,136
1901...	6,965	6,287	903	1944...	7,301	8,055	1,103
1902...	6,966	4,949	710	1945...	7,088	5,910	834
1903...	7,004	6,227	889	1946...	6,871	8,444	1,229
1904...	7,040	6,891	979	1947...	7,293	8,310	1,139
1905...	7,046	5,115	726	1948...	7,307	9,140	1,251
1906...	7,074	6,200	876	1949...	7,330	8,605	1,174
1907...	7,103	6,572	925	1950...	7,441	8,850	1,189
1908...	7,143	6,958	974	1951...	7,453	8,291	1,112
1909...	7,181	7,025	978	1952...	7,436	9,099	1,224
1910...	7,209	6,247	867	1953...	7,449	7,555	986
1911...	7,267	6,928	953	1954...	7,539	8,357	1,109
1912...	7,339	6,727	917	1955...	7,961	11,357	1,427
1913...	7,405	6,730	909	1956...	8,013	9,918	1,238
1914...	7,415	7,638	1,030	1957...	8,003	10,432	1,304
1915...	7,422	7,491	1,009	1958...	8,039	10,914	1,358
1916...	7,507	7,829	1,043	1959...	8,125	11,376	1,400
1917...	7,538	7,307	969	1960...	8,175	11,728	1,435
1918...	7,563	7,328	969	1961...	8,157	11,388	1,396
1919...	7,591	8,147	1,073	1962...	8,117	11,929	1,470
1920...	7,644	8,466	1,108	1963...	3,075	11,777	1,458

[1] In terms of milled rice.
[2] Calculations based on unrounded figures.

Source: 1878-1950, Japanese Crop and Livestock Statistics, 1878-1950; 1951-60, Abstract of Statistics on Agriculture, Forestry and Fisheries; 1961-1963, Reports from office of U.S. Agricultural Attaché, Tokyo.

Table 31.--Japan--wheat and barley: Area, production and yield per acre, 1878-1963

Year	Area	Production	Yield per acre[1]	Year	Area	Production	Yield per acre[1]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1878...	3,346	1,136	340	1921..	4,188	2,658	635
1879...	3,472	1,191	343	1922..	3,966	2,661	671
1880...	3,501	1,483	424	1923..	3,739	2,290	612
1881...	3,506	1,273	363	1924..	3,600	2,334	648
1882...	3,578	1,520	425	1925..	3,608	2,808	778
1883...	3,645	1,455	399	1926..	3,571	2,705	757
1884...	3,647	1,568	430	1927..	3,496	2,603	745
1885...	3,763	1,458	387	1928..	3,435	2,624	764
1886...	3,889	1,946	500	1929..	3,400	2,592	762
1887...	3,899	1,933	496	1930..	3,314	2,392	722
1888...	3,973	1,862	469	1931..	3,319	2,581	778
1889...	4,060	1,856	458	1932..	3,348	2,621	783
1890...	4,171	1,285	308	1933..	3,427	2,589	755
1891...	4,198	2,209	526	1934..	3,435	2,865	840
1892...	4,258	1,959	460	1935..	3,536	3,031	857
1893...	4,275	2,039	477	1936..	3,595	2,726	758
1894...	4,290	2,431	567	1937..	3,632	2,942	810
1895...	4,342	2,391	551	1938..	3,664	2,624	716
1896...	4,324	2,113	489	1939..	3,692	3,434	930
1897...	4,280	2,193	512	1940..	3,882	3,477	896
1898...	4,421	2,506	567	1941..	4,045	3,101	767
1899...	4,416	2,351	532	1942..	4,324	3,035	702
1900...	4,398	2,499	568	1943..	4,104	2,397	584
1901...	4,445	2,529	569	1944..	4,344	3,078	709
1902...	4,416	2,251	510	1945..	3,959	2,199	555
1903...	4,403	1,612	366	1946..	3,573	1,483	415
1904...	4,406	2,394	543	1947..	3,294	1,923	584
1905...	4,445	2,283	514	1948..	4,267	3,024	709
1906...	4,438	2,476	558	1949..	4,364	3,306	758
1907...	4,398	2,694	613	1950..	4,408	3,297	748
1908...	4,361	2,621	601	1951..	4,235	3,658	864
1909...	4,337	2,641	609	1952..	4,079	3,695	906
1910...	4,334	2,511	579	1953..	3,971	3,465	873
1911...	4,319	2,683	621	1954..	4,166	4,098	984
1912...	4,342	2,803	646	1955..	4,099	3,875	945
1913...	4,475	3,076	687	1956..	4,050	3,716	918
1914...	4,460	2,590	581	1957..	3,833	3,490	911
1915...	4,433	2,913	657	1958..	3,747	3,348	894
1916...	4,371	2,871	657	1959..	3,692	3,724	1,009
1917...	4,275	2,989	699	1960..	3,558	3,831	1,077
1918...	4,245	2,806	660	1961..	3,314	3,757	1,134
1919...	4,230	2,924	691	1962..	3,096	3,356	1,084
1920...	4,287	2,793	652	1963..	2,842	1,475	519

[1] Calculations based on unrounded figures.

Source: 1878-1950, Japanese Crop and Livestock Statistics, 1878-1950; 1951-1960, Abstract of Statistics on Agriculture, Forestry and Fisheries; 1961-1963, Reports from office of U.S. Agricultural Attaché, Tokyo.

Table 32.--United Kingdom--all grains combined: Area, production and yield per acre, 1884-1963[1]

Year	Area	Production	Yield per acre
	1,000 acres	1,000 metric tons	Kilograms
1884...	7,761	5,844	753
1885...	7,675	5,875	765
1886...	7,609	5,423	713
1887...	7,490	5,451	728
1888...	7,532	5,459	725
1889...	7,460	5,579	748
1890...	7,400	5,854	791
1891...	7,319	[illegible]	770
1892...	7,255	[illegible]	731
1893...	7,145	4,738	663
1894...	7,277	5,708	784
1895...	6,879	4,785	696
1896...	6,894	5,227	758
1897...	6,961	5,130	737
1898...	6,924	5,689	822
1899...	6,943	5,401	778
1900...	6,861	4,930	719
1901...	6,669	4,812	722
1902...	6,692	5,416	809
1903...	6,580	4,908	746
1904...	6,469	4,613	713
1905...	6,562	5,034	767
1906...	6,550	5,220	797
1907...	6,460	5,309	822
1908...	6,403	4,914	767
1909...	6,469	5,286	817
1910...	6,559	4,985	760
1911...	6,515	4,936	758
1912...	6,603	4,677	708
1913...	6,426	4,837	753
1914...	6,416	5,006	780
1915...	6,699	5,076	758
1916...	6,552	4,775	729
1917...	6,898	5,126	743
1918...	8,314	6,625	797
1919...	7,659	5,379	702
1920...	7,075	5,143	727
1921...	[illegible]	5,218	766
1922...	6,705	4,837	721
1923...	6,231	4,644	745
1924..	6,053	4,723	780
1925..	5,813	4,546	782
1926..	5,720	4,520	790
1927..	5,518	4,417	800
1928..	5,391	4,463	828
1929..	5,345	4,598	860
1930..	5,167	3,953	765
1931..	4,851	3,720	767
1932..	4,817	3,924	815
1933..	4,901	4,153	847
1934..	5,033	4,333	861
1935..	4,987	4,219	846
1936..	4,938	3,926	795
1937..	4,778	3,714	777
1938..	5,005	4,378	875
1939..	4,908	4,217	859
1940..	6,547	5,727	875
1941..	7,691	6,511	847
1942..	8,177	7,687	940
1943..	8,930	8,286	928
1944..	8,849	7,968	900
1945..	8,242	7,650	928
1946..	7,840	6,943	886
1947..	7,531	5,888	782
1948..	7,697	7,470	970
1949..	7,275	7,445	1,023
1950..	7,362	7,121	967
1951..	6,896	6,981	1,012
1952..	7,193	7,531	1,047
1953..	7,283	8,134	1,117
1954..	7,108	7,587	1,067
1955..	6,825	8,376	1,227
1956..	7,180	8,262	1,151
1957..	7,083	7,909	1,117
1958..	7,180	8,148	1,135
1959..	7,020	9,132	1,301
1960..	7,448	9,440	1,267
1961..	7,388	9,519	1,288
1962..	7,755	11,320	1,460
1963..	7,940	11,024	1,388

[1] Includes wheat, barley and oats. Northern Ireland included after 1939.

Source: Compiled from tables 33, 34, and 35.

Table 33.--United Kingdom--wheat: Area, production and yield per acre, 1884-1963[1]

Year	Area	Production	Yield per acre	Year	Area	Production	Yield per acre
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1884...	2,677	2,183	815	1924...	1,594	1,405	881
1885...	2,478	2,112	852	1925...	1,548	1,388	897
1886...	2,286	1,673	732	1926...	1,646	1,339	813
1887...	2,317	2,023	873	1927...	1,703	1,484	871
1888...	2,564	1,958	764	1928...	1,454	1,293	889
1889...	2,449	1,992	813	1929...	1,381	1,287	932
1890...	2,386	1,996	837	1930...	1,400	1,127	805
1891...	2,307	1,963	851	1931...	1,247	1,010	810
1892...	2,220	1,594	718	1932...	1,340	1,149	857
1893...	1,898	1,340	706	1933...	1,739	1,618	930
1894...	1,928	1,610	835	1934...	1,857	1,812	976
1895...	1,417	1,012	714	1935...	1,873	1,706	911
1896...	1,694	1,553	917	1936...	1,798	1,472	819
1897...	1,889	1,495	791	1937...	1,832	1,481	808
1898...	2,102	1,988	946	1938...	1,923	1,915	996
1899...	2,001	1,783	891	1939...	1,763	1,618	918
1900...	1,845	1,433	777	1940...	1,809	1,667	922
1901...	1,701	1,428	840	1941...	2,265	2,050	905
1902...	1,726	1,542	893	1942...	2,516	2,608	1,037
1903...	1,582	1,297	820	1943...	3,464	3,502	1,011
1904...	1,375	1,004	730	1944...	3,220	3,188	990
1905...	1,797	1,603	892	1945...	2,274	2,211	972
1906...	1,756	1,608	916	1946...	2,062	1,999	969
1907...	1,625	1,502	924	1947...	2,163	1,694	783
1908...	1,627	1,430	879	1948...	2,279	2,399	1,053
1909...	1,823	1,672	917	1949...	1,963	2,239	1,141
1910...	1,809	1,494	826	1950...	2,479	2,648	1,068
1911...	1,966	1,705	895	1951...	2,131	2,353	1,104
1912...	1,926	1,520	789	1952...	2,030	2,344	1,155
1913...	1,756	1,502	859	1953...	2,217	2,707	1,221
1914...	1,868	1,661	889	1954...	2,457	2,828	1,151
1915...	2,247	1,924	856	1955...	1,948	2,641	1,356
1916...	1,975	1,550	785	1956...	2,293	2,891	1,261
1917...	1,979	1,626	822	1957...	2,113	2,726	1,290
1918...	2,636	2,330	903	1958...	2,208	2,755	1,248
1919...	2,301	1,820	791	1959...	1,929	2,830	1,467
1920...	1,929	1,509	782	1960...	2,102	3,040	1,446
1921...	2,041	1,969	965	1961...	1,827	2,614	1,431
1922...	2,032	1,737	855	1962...	2,256	3,689	1,635
1923...	1,799	1,557	865	1963...	1,926	2,896	1,504

[1] Northern Ireland included after 1939.

Source: 1884-1939, Abstract of British Historical Statistics; 1940-61, Annual Abstract of Statistics; 1962-63, Reports from Office of U.S. Agricultural Attaché, London.

Table 34.--United Kingdom--barley: Area, production and yield per acre, 1884-1963[1]

Year	Area	Production	Yield per acre	Year	Area	Production	Yield per acre
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1884...	2,169	1,676	773	1924..	1,466	1,085	740
1885...	2,257	1,797	796	1925..	1,471	1,077	732
1886...	2,241	1,635	730	1926..	1,270	958	754
1887...	2,085	1,481	710	1927..	1,166	905	776
1888...	2,086	1,553	744	1928..	1,296	1,037	800
1889...	2,122	1,529	721	1929..	1,221	1,033	846
1890...	2,111	1,677	794	1930..	1,127	797	707
1891...	2,113	1,636	774	1931..	1,117	808	723
1892...	2,037	1,599	785	1932..	1,029	785	763
1893...	2,075	1,350	651	1933..	811	635	783
1894...	2,096	1,640	782	1934..	957	755	789
1895...	2,166	1,557	719	1935..	868	684	788
1896...	2,105	1,605	762	1936..	891	691	776
1897...	2,036	1,515	744	1937..	904	617	683
1898...	1,904	1,543	810	1938..	984	839	853
1899...	1,982	1,536	775	1939..	1,010	831	823
1900...	1,990	1,413	710	1940..	1,339	1,122	838
1901...	1,972	1,386	703	1941..	1,475	1,162	788
1902...	1,909	1,508	790	1942..	1,528	1,469	961
1903...	1,858	1,349	726	1943..	1,786	1,671	936
1904...	1,841	1,297	704	1944..	1,973	1,780	902
1905...	1,714	1,318	769	1945..	2,215	2,142	967
1906...	1,751	1,373	784	1946..	2,211	1,994	902
1907...	1,712	1,369	800	1947..	2,060	1,645	799
1908...	1,667	1,241	744	1948..	2,083	2,060	989
1909...	1,664	1,382	831	1949..	2,060	2,163	1,050
1910...	1,729	1,281	741	1950..	1,778	1,738	978
1911...	1,598	1,156	723	1951..	1,908	1,970	1,032
1912...	1,648	1,162	705	1952..	2,281	2,371	1,039
1913...	1,757	1,314	748	1953..	2,226	2,561	1,150
1914...	1,699	1,288	758	1954..	2,063	2,280	1,105
1915...	1,381	935	677	1955..	2,296	2,983	1,299
1916...	1,502	1,057	704	1956..	2,323	2,845	1,225
1917...	1,619	1,132	699	1957..	2,622	3,004	1,146
1918...	1,654	1,226	741	1958..	2,755	3,221	1,169
1919...	1,683	1,132	673	1959..	3,059	4,080	1,334
1920...	1,842	1,326	720	1960..	3,372	4,309	1,278
1921...	1,606	1,097	683	1961..	3,828	5,054	1,320
1922...	1,521	1,053	692	1962..	3,980	5,856	1,471
1923...	1,486	1,034	696	1963..	4,707	6,604	1,403

[1] Northern Ireland included after 1939.

Source: 1884-1939, Abstract of British Historical Statistics; 1940-61, Annual Abstract of Statistics; 1962-63, Reports from office of U.S. Agricultural Attaché, London.

Table 35.--United Kingdom - oats: Area, production and yield per acre, 1884-1963[1]

Year	Area	Production	Yield per acre	Year	Area	Production	Yield per acre
	1,000 acres	1,000 metric tons	Kilograms		1,000 acres	1,000 metric tons	Kilograms
1884...	2,915	1,985	681	1924...	2,993	2,233	746
1885...	2,940	1,966	669	1925...	2,794	2,081	745
1886...	3,082	2,115	686	1926...	2,804	2,223	793
1887...	3,088	1,947	630	1927...	2,649	2,028	766
1888...	2,882	1,948	676	1928...	2,641	2,133	808
1889...	2,889	2,058	712	1929...	2,743	2,278	830
1890...	2,903	2,181	751	1930...	2,640	2,029	769
1891...	2,873	2,039	705	1931...	2,487	1,902	765
1892...	2,998	2,113	704	1932...	2,448	1,995	815
1893...	3,172	2,049	646	1933...	2,351	1,[illegible]	808
1894...	3,253	2,458	756	1934...	2,219	1,766	796
1895...	3,296	2,216	672	1935...	2,246	1,829	814
1896...	3,095	2,069	668	1936...	2,249	1,763	784
1897...	3,036	2,120	698	1937...	2,[illegible]	1,616	791
1898...	2,918	2,158	740	1938...	2,098	1,624	774
1899...	2,96[illegible]	2,[illegible]92	7[illegible]	1939...	2,135	1,768	823
1900...	3,026	2,084	689	1940...	3,394	2,938	864
1901...	2,996	1,998	667	1941...	3,951	3,299	825
1902...	3,057	2,366	774	1942...	4,133	3,613	873
1903...	3,14[illegible]	2,262	723	1943...	3,680	3,115	846
1904...	3,053	2,512	711	1944...	3,658	3,046	821
1905...	3,051	2,113	693	1945...	3,753	3,297	878
1906...	3,042	2,239	736	1946...	3,467	2,9[illegible]	827
1907...	3,122	2,438	781	1947...	3,3[illegible]8	2,584	771
1908...	3,107	2,243	721	1948...	3,3[illegible]	3,011	905
1909...	2,982	2,232	748	1949...	3,[illegible]52	3,[illegible]	930
1910...	3,021	2,21[illegible]	732	1950...	3,1[illegible]	2,[illegible]	881
1911...	3,011	2,075	689	1951...	2,859	2,658	930
1912...	3,029	1,995	659	1952...	2,682	2,810	977
1913...	2,915	2,01[illegible]	692	1953...	2,846	2,[illegible]	1,0[illegible]
1914...	2,949	2,0[illegible]	722	1954...	2,588	2,479	958
1915...	3,001	2,217	722	1955...	2,581	2,752	1,066
1916...	3,095	2,168	705	1956...	2,364	2,326	985
1917...	3,5[illegible]	2,368	718	1957...	2,348	2,173	928
1918...	4,024	3,019	750	1958...	2,217	2,172	980
1919...	3,67[illegible]	2,427	666	1959...	2,049	2,222	1,094
1920...	3,304	2,308	699	1960...	1,974	2,091	1,059
1921...	3,161	2,152	681	1961...	1,733	1,851	1,068
1922...	3,152	2,067	649	1962...	1,519	1,775	1,169
1923...	2,946	2,093	697	1963...	1,307	1,524	1,166

[1] Northern Ireland included after 1939.

Source: 1884-1939, Abstract of British Historical Statistics; 1940-61, Annual Abstract of Statistics; 1962-63, Reports from Office of U.S. Agricultural Attaché, London.

Table 36.--United States--all grains combined: Area, production and yield per acre, 1866-1963[1]

Year	Area	Production	Yield per acre[2]	Year	Area	Production	Yield per acre[2]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1866...	53,360	26,556	498	1915...	211,164	126,191	598
1867...	57,030	29,136	511	1916...	205,163	100,497	490
1868...	63,153	33,395	529	1917...	213,754	117,648	550
1869...	66,582	31,868	479	1918...	222,735	114,914	516
1870...	69,681	39,384	565	1919...	215,637	106,893	496
1871...	75,293	40,845	542	1920...	208,820	118,368	567
1872...	78,335	44,630	570	1921...	214,973	107,381	500
1873...	80,960	38,830	480	1922...	201,003	102,792	511
1874...	87,725	40,541	462	1923...	224,889	105,529	469
1875...	94,444	50,675	537	1924...	190,258	96,231	506
1876...	98,149	50,711	517	1925...	196,354	104,819	534
1877...	101,578	55,588	547	1926...	195,105	98,815	506
1878...	108,868	58,401	536	1927...	197,851	103,129	521
1879...	113,531	63,031	555	1928...	202,213	110,078	544
1880...	117,055	63,117	539	1929...	205,824	101,627	494
1881...	116,737	49,143	421	1930...	208,727	96,542	463
1882...	121,728	67,460	554	1931...	208,776	106,205	509
1883...	124,376	62,698	504	1932...	218,594	114,045	522
1884...	129,293	74,323	575	1933...	195,280	84,917	435
1885...	130,300	72,940	560	1934...	145,753	55,327	380
1886...	134,649	69,165	514	1935...	195,881	95,226	486
1887...	136,441	64,219	471	1936...	165,409	65,890	398
1888...	140,250	79,927	570	1937...	200,741	109,109	544
1889...	142,451	84,068	590	1938...	208,499	108,695	521
1890...	139,746	62,986	451	1939...	186,802	102,669	550
1891...	147,701	89,919	609	1940...	189,319	107,271	567
1892...	148,061	75,326	509	1941...	196,578	116,712	594
1893...	149,888	72,303	482	1942...	199,302	131,387	659
1894...	149,792	66,658	445	1943...	198,073	118,707	599
1895...	160,382	92,565	577	1944...	209,791	128,907	614
1896...	160,150	93,329	583	1945...	204,961	127,505	622
1897...	162,207	86,648	534	1946...	208,555	136,779	656
1898...	167,617	92,858	554	1947...	206,350	117,813	571
1899...	176,187	98,640	560	1948...	211,622	152,301	720
1900...	175,104	97,653	558	1949...	210,696	133,052	631
1901...	176,160	75,945	431	1950...	198,202	132,075	666
1902...	174,779	104,789	600	1951...	189,983	123,873	652
1903...	174,198	94,787	544	1952...	196,447	135,760	691
1904...	171,132	98,047	573	1953...	194,678	132,231	679
1905...	175,478	110,285	628	1954...	193,008	132,836	688
1906...	175,542	112,039	638	1955...	186,068	137,537	739
1907...	174,672	95,135	545	1956...	173,232	137,611	794
1908...	174,697	94,731	542	1957...	178,496	148,199	830
1909...	190,095	104,506	550	1958...	182,370	172,587	940
1910...	195,378	109,716	562	1959...	185,028	168,414	910
1911...	199,137	96,799	486	1960...	183,001	180,579	987
1912...	198,017	119,959	606	1961...	161,211	163,517	1,014
1913...	200,947	98,060	488	1962...	150,574	162,311	1,078
1914...	202,065	109,265	541	1963...	156,074	175,239	1,123

[1] Total includes only wheat, corn and oats in early years; rice, rye and barley added in 1909; grain sorghums added in 1929.
[2] Calculations based on unrounded figures.

Source: Compiled from individual grain tables.

Table [illegible].--United States--corn: Area, production and yield per acre, 1866-1963

Year	Area	Production	Yield per acre[1]	Year	Area	Production	Yield per acre[1]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1866...	30,017	13,564	617	1915..	100,623	71,862	714
1867...	32,116	20,166	627	1916..	100,561	61,604	612
1868...	35,116	23,359	666	1917..	110,893	73,874	666
1869...	35,833	19,866	554	1918..	102,195	62,011	607
1870...	38,388	28,571	744	1919..	87,487	59,486	681
1871...	42,002	29,001	691	1920..	90,149	68,456	759
1872...	43,584	32,498	747	1921..	91,939	64,948	706
1873...	44,084	25,613	582	1922..	84,858	56,631	668
1874...	47,640	26,894	564	1923..	87,493	61,713	706
1875...	52,446	36,839	704	1924..	84,119	47,249	561
1876...	55,277	37,548	678	1925..	86,825	60,512	696
1877...	58,799	38,505	655	1926..	83,275	54,363	653
1878...	59,659	39,741	666	1927..	83,915	56,344	671
1879...	62,229	44,503	716	1928..	85,832	57,431	668
1880...	62,545	43,352	693	1929..	83,194	54,232	653
1881...	63,026	31,620	503	1930..	85,525	44,637	521
1882...	66,157	44,586	673	1931..	91,131	56,642	622
1883...	68,168	41,967	615	1932..	97,213	65,501	673
1884...	68,834	49,478	719	1933..	92,130	53,462	579
1885...	71,854	52,271	726	1934..	61,245	29,128	475
1886...	73,911	45,285	612	1935..	82,551	50,837	615
1887...	73,296	40,758	556	1936..	67,833	31,972	472
1888...	77,474	57,169	739	1937..	81,222	59,678	734
1889...	77,656	58,278	749	1938..	82,788	58,425	706
1890...	74,785	41,924	561	1939..	78,307	59,479	759
1891...	78,855	59,333	752	1940..	76,443	56,057	734
1892...	76,914	48,197	627	1941..	77,404	61,329	793
1893...	79,832	48,273	605	1942..	79,213	71,169	899
1894...	80,069	41,024	513	1943..	81,906	67,782	828
1895...	90,479	64,387	711	1944..	85,002	71,164	838
1896...	89,074	67,848	762	1945..	77,928	65,470	841
1897...	89,965	58,109	645	1946..	78,410	74,072	945
1898...	87,784	59,727	681	1947..	73,802	53,553	726
1899...	94,591	67,207	711	1948..	76,840	84,002	1,092
1900...	94,852	67,618	714	1949..	77,106	74,837	970
1901...	94,422	43,583	462	1950..	72,398	70,210	970
1902...	97,177	70,462	724	1951..	71,191	66,774	938
1903...	93,555	63,887	683	1952..	71,353	75,717	1,061
1904...	95,228	68,244	716	1953..	70,738	73,198	1,035
1905...	95,746	75,040	785	1954..	68,668	68,781	1,002
1906...	95,624	77,040	805	1955..	68,462	72,972	1,066
1907...	96,094	66,394	691	1956..	64,877	78,113	1,188
1908...	95,285	65,199	683	1957..	63,065	77,353	1,227
1909...	100,200	66,327	663	1958..	63,549	85,248	1,341
1910...	102,267	72,465	709	1959..	72,091	97,145	1,348
1911...	101,393	62,859	620	1960..	71,649	99,265	1,385
1912...	101,451	74,879	739	1961..	58,449	92,088	1,575
1913...	100,206	57,726	577	1962..	56,609	92,372	1,632
1914...	97,796	64,107	655	1963..	60,654	103,678	1,712

[1] Calculations based on unrounded figures.

Source: Agricultural Statistics 1962; 1919-1943, Corn acreage, yield and production, AMS; Statistical Bulletins No. 108 and 185.

Table 38.--United States--wheat: Area, production and yield per acre, 1866-1963

Year	Area	Production	Yield per acre[1]
	1,000 acres	1,000 metric tons	Kilograms
1866...	15,408	4,619	299
1867...	16,738	5,739	343
1868...	19,140	6,702	351
1869...	21,194	7,880	373
1870...	20,945	6,924	329
1871...	22,230	7,399	332
1872...	22,962	7,389	321
1873...	24,866	8,762	351
1874...	27,310	9,692	354
1875...	28,382	8,538	302
1876...	28,283	8,413	297
1877...	27,963	10,764	384
1878...	33,379	12,225	367
1879...	35,347	12,498	354
1880...	38,096	13,699	359
1881...	36,795	11,047	299
1882...	36,496	15,029	411
1883...	35,587	11,942	335
1884...	38,485	15,548	402
1885...	35,095	10,884	310
1886...	36,312	13,976	384
1887...	36,873	13,356	362
1888...	34,969	11,536	329
1889...	36,098	13,727	381
1890...	36,686	12,221	332
1891...	41,090	18,440	449
1892...	42,979	16,652	386
1893...	40,790	13,766	337
1894...	40,167	14,748	367
1895...	38,998	14,754	378
1896...	40,828	14,233	348
1897...	43,413	16,498	381
1898...	50,506	20,906	414
1899...	52,342	17,830	340
1900...	49,203	16,311	332
1901...	50,847	20,753	408
1902...	46,244	18,696	406
1903...	48,456	18,047	373
1904...	43,155	15,120	351
1905...	46,306	19,215	414
1906...	46,230	20,154	435
1907...	44,139	17,112	386
1908...	45,102	17,495	389
1909...	44,262	18,614	422
1910...	45,793	17,023	373
1911...	49,894	16,824	337
1912...	48,413	19,868	411
1913...	52,012	20,442	392
1914...	55,613	24,426	438
1915...	60,303	27,451	455
1916...	53,510	17,270	324
1917...	46,787	16,868	359
1918...	61,068	24,607	403
1919...	73,700	25,912	351
1920...	62,358	22,950	367
1921...	64,566	22,289	346
1922...	61,397	23,042	376
1923...	56,920	20,670	362
1924...	52,463	22,905	435
1925...	52,443	18,199	348
1926...	56,616	22,649	400
1927...	59,628	23,815	400
1928...	59,226	24,885	419
1929...	63,392	22,431	354
1930...	62,637	24,127	386
1931...	57,704	25,625	444
1932...	57,851	20,584	357
1933...	49,424	15,029	305
1934...	43,347	14,317	329
1935...	51,305	17,098	332
1936...	49,125	17,143	348
1937...	64,169	23,784	370
1938...	69,197	25,036	362
1939...	52,669	20,173	384
1940...	53,273	22,171	416
1941...	55,935	25,636	457
1942...	49,773	26,382	531
1943...	51,355	22,965	446
1944...	59,749	28,852	482
1945...	65,167	30,145	463
1946...	67,105	31,356	468
1947...	74,519	36,984	495
1948...	72,418	35,242	487
1949...	75,910	29,894	395
1950...	61,607	27,742	449
1951...	61,873	26,894	435
1952...	71,130	35,556	501
1953...	67,840	31,926	471
1954...	54,356	26,778	493
1955...	47,290	25,504	539
1956...	49,768	27,363	550
1957...	43,754	26,011	593
1958...	53,047	39,665	748
1959...	51,781	30,512	591
1960...	51,896	36,939	713
1961...	51,551	33,604	652
1962...	43,545	29,714	682
1963...	45,256	30,961	684

[1] Calculations based on unrounded figures.

Source: 1866-1961, Agricultural Statistics 1962; 1961-1962, Wheat Situation.

Table 39.--United States--oats: Area, production and yield per acre, 1866-1963[1]

Year	Area	Production	Yield per acre[2]	Year	Area	Production	Yield per acre[2]
	1,000 acres	1,000 metric tons	Kilograms		1,000 acres	1,000 metric tons	Kilograms
1866...	7,935	3,373	425	1915...	38,802	20,833	537
1867...	8,176	3,231	395	1916...	39,098	16,532	422
1868...	8,897	3,334	374	1917...	41,604	20,938	504
1869...	9,555	4,122	431	1918...	42,464	20,736	488
1870...	10,348	3,889	376	1919...	39,601	16,062	405
1871...	11,061	4,445	402	1920...	42,732	20,964	491
1872...	11,789	4,743	402	1921...	45,539	15,172	334
1873...	12,010	4,455	372	1922...	40,324	16,662	414
1874...	12,775	3,955	309	1923...	40,245	17,813	443
1875...	13,616	5,298	389	1924...	41,857	20,555	491
1876...	14,589	4,750	325	1925...	44,240	20,398	462
1877...	14,816	6,319	427	1926...	42,854	16,735	390
1878...	15,830	6,435	406	1927...	40,350	15,868	393
1879...	15,955	6,030	377	1928...	40,128	19,057	475
1880...	16,414	6,066	370	1929...	38,153	16,155	424
1881...	16,916	6,476	383	1930...	39,847	18,501	464
1882...	19,075	7,845	411	1931...	40,193	16,318	406
1883...	20,621	8,790	427	1932...	41,700	18,210	437
1884...	21,974	9,297	422	1933...	36,528	10,688	293
1885...	23,351	9,785	419	1934...	29,455	7,900	269
1886...	24,426	9,904	405	1935...	40,109	17,567	438
1887...	26,272	10,105	385	1936...	33,654	11,504	343
1888...	27,807	11,222	404	1937...	35,542	17,081	480
1889...	28,697	12,063	421	1938...	36,042	15,813	438
1890...	28,275	8,841	312	1939...	33,460	13,901	415
1891...	27,756	12,146	437	1940...	35,431	18,092	511
1892...	28,168	10,477	372	1941...	38,161	17,164	450
1893...	29,266	10,264	351	1942...	38,197	19,489	510
1894...	29,556	10,886	369	1943...	38,914	16,545	425
1895...	30,905	13,424	434	1944...	39,741	16,681	419
1896...	30,248	11,248	372	1945...	41,739	22,119	530
1897...	28,829	12,041	418	1946...	42,812	21,447	501
1898...	29,327	12,225	417	1947...	37,855	17,072	451
1899...	29,254	13,603	464	1948...	39,280	21,050	536
1900...	31,049	13,724	443	1949...	37,794	17,710	469
1901...	30,891	11,609	376	1950...	39,306	19,874	505
1902...	31,358	15,631	498	1951...	35,233	18,545	527
1903...	32,187	12,853	399	1952...	37,012	17,671	478
1904...	32,749	14,683	449	1953...	37,536	16,739	446
1905...	33,426	16,030	479	1954...	40,551	20,461	505
1906...	33,688	14,845	441	1955...	39,027	21,714	556
1907...	34,439	11,629	338	1956...	33,333	16,713	501
1908...	34,310	12,037	351	1957...	34,065	18,723	550
1909...	35,062	14,717	419	1958...	31,247	20,342	650
1910...	36,844	16,056	43[illegible]	1959...	27,793	15,271	550
1911...	37,149	12,854	345	1960...	26,646	16,769	630
1912...	37,244	19,643	527	1961...	24,077	14,702	611
1913...	37,245	15,083	405	1962...	22,675	14,806	653
1914...	37,213	15,478	417	1963...	21,757	14,233	654

[1] Prior to 1949, includes an allowance for oats cut ripe for feeding, unthreshed.

[2] Calculations based on unrounded figures.

Source: 1866-1961, Agricultural Statistics, 1962; 1961-1962, Feed Situation.

Table 40.--United States--barley: Area, production and yield per acre, 1909-1963

Year	Area	Production	Yield per acre[1]	Year	Area	Production	Yield per acre[1]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1909...	7,697	3,768	490	1937...	9,969	4,831	486
1910...	7,546	3,101	412	1938...	10,610	5,587	527
1911...	7,613	3,159	416	1939...	12,739	6,057	475
1912...	7,542	4,288	568	1940...	13,525	6,777	501
1913...	7,673	3,458	451	1941...	14,276	7,894	553
1914...	7,653	3,869	505	1942...	16,958	9,350	551
1915...	7,279	4,506	618	1943...	14,900	7,031	472
1916...	7,623	3,465	455	1944...	12,301	6,015	490
1917...	8,453	3,967	470	1945...	10,454	5,813	555
1918...	9,198	4,900	533	1946...	10,380	5,771	555
1919...	6,579	2,854	433	1947...	10,995	6,137	560
1920...	7,439	3,724	501	1948...	11,905	6,870	577
1921...	7,074	2,889	409	1949...	9,872	5,162	523
1922...	6,601	3,329	505	1950...	11,155	6,614	592
1923...	7,151	3,462	483	1951...	9,424	5,600	594
1924...	7,038	3,599	512	1952...	8,236	4,968	603
1925...	8,186	4,190	512	1953...	8,680	5,372	618
1926...	7,917	3,615	457	1954...	13,370	8.257	618
1927...	9,465	5,205	551	1955...	14,523	8,776	605
1928...	12,735	7,149	562	1956...	12,852	8,201	638
1929...	13,564	6,110	451	1957...	14,872	9,640	649
1930...	12,629	6,567	520	1958...	14,791	10,394	703
1931...	11,181	4,361	390	1959...	14,918	9,196	616
1932...	13,206	6,519	494	1960...	13,939	9,391	673
1933...	9,641	3,328	346	1961...	12,969	8,565	660
1934...	6,577	2,556	388	1962...	12,430	9,502	764
1935...	12,436	6,285	505	1963...	11,538	8,707	755
1936...	8,329	3,217	385				

[1] Calculations based on unrounded figures.

Source: 1909-1961, Agricultural Statistics, 1962; 1961-1962, Feed Situation.

Table 41.--United States--rice: Area, production and yield per acre, 1909-1963

Year	Area	Production[1]	Yield per acre [1 2]	Year	Area	Production[1]	Yield per acre [1 2]
	1,000 acres	1,000 metric tons	Kilo-grams		1,000 acres	1,000 metric tons	Kilo-grams
1909..	662	316	478	1937..	1,099	717	653
1910..	666	332	499	1938..	1,076	705	655
1911..	636	305	478	1939..	1,045	726	695
1912..	642	318	495	1940..	1,069	731	684
1913..	722	325	450	1941..	1,214	690	568
1914..	646	315	488	1942..	1,457	868	595
1915..	740	351	474	1943..	1,472	873	594
1916..	843	531	630	1944..	1,480	924	624
1917..	953	467	489	1945..	1,499	916	611
1918..	1,101	537	488	1946..	1,582	970	613
1919..	1,083	576	532	1947..	1,708	1,051	615
1920..	1,299	694	534	1948..	1,804	1,142	634
1921..	990	528	533	1949..	1,858	1,217	655
1922	1,053	559	531	1950..	1,637	1,159	707
1923..	874	446	511	1951..	1,996	1,376	689
1924..	838	438	523	1952..	1,997	1,438	721
1925..	853	443	520	1953..	2,159	1,577	730
1926..	1,016	565	555	1954..	2,550	1,916	751
1927..	1,027	597	582	1955..	1,826	1,669	913
1928..	972	589	605	1956..	1,569	1,476	940
1929..	860	531	617	1957..	1,340	1,282	956
1930..	966	603	624	1958..	1,415	1,336	944
1931..	965	599	620	1959..	1,586	1,601	1,009
1932..	874	559	640	1960..	1,595	1,629	1,022
1933..	798	506	634	1961..	1,589	1,601	1,007
1934..	812	524	646	1962..	1,765	1,924	1,090
1935..	817	530	649	1963..	1,770	2,092	1,181
1936..	981	669	682				

[1] In terms of milled rice.
[2] Calculations based on unrounded figures.

Source: 1909-1961, Agricultural Statistics; 1962-1963, Rice Situation.

Table 42.--United States--grain sorghum: Area, production and yield per acre, 1929-1963

Year	Area	Production	Yield per acre[1]
	1,000 acres	1,000 metric tons	Kilograms
1929............	3,523	1,269	361
1930............	3,477	954	274
1931............	4,443	1,827	412
1932............	4,400	1,679	381
1933............	4,354	1,381	318
1934............	2,396	488	203
1935............	4,597	1,463	318
1936............	2,793	769	274
1937............	4,915	1,777	257
1938............	4,699	1,707	363
1939............	4,760	1,353	284
1940............	6,374	2,434	381
1941............	6,015	2,884	480
1942............	5,991	2,785	465
1943............	6,889	2,782	404
1944............	9,386	4,699	500
1945............	6,324	2,440	386
1946............	6,669	2,693	404
1947............	5,480	2,368	432
1948............	7,317	3,337	457
1949............	6,600	3,772	572
1950............	10,346	5,932	574
1951............	8,544	4,137	485
1952............	5,326	2,305	432
1953............	6,295	2,939	467
1954............	11,718	5,984	511
1955............	12,891	6,163	478
1956............	9,209	5,204	564
1957............	19,682	14,466	732
1958............	16,524	14,759	894
1959............	15,402	14,103	914
1960............	15,592	15,746	1,011
1961............	11,026	12,259	1,113
1962............	11,536	12,947	1,122
1963............	13,488	14,821	1,099

[1] Calculations based on unrounded figures.

Source: 1929-1961, Agricultural Statistics 1962; 1962-1963 Feed Situation.

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