Rockefeller Foundation Collaboration in Agricultural Research in Mexico[1]

E. J. WELLHAUSEN[2]

AT THE time of the Spanish Conquest early in the 16th Century, there were from 7 to 8,000,000 Indians inhabiting the territory now known as Mexico. Some Indian tribes lived by hunting and fishing but others were rather highly organized and developed a sedentary, agricultural type of society in which the possession and use of land became a matter of the greatest importance. These highly organized tribes lived in Yucatan and on the south-central plateau on some of the best agricultural land of Mexico. From the time of the Conquest the population of Mexico has increased and today it is estimated at 22,000,000 inhabitants. Of these about 60% are mestizos (mixed races), 30% pure blooded Indians, and about 10% foreigners.

To support these 22,000,000 inhabitants has become one of Mexico's major problems and chief concerns in recent years. There is not enough production of the major food crops such as corn, wheat, and beans to provide an adequate standard of living for all of the population. Rural production barely provides enough for the rural population and so Mexico has had to import large amounts of corn and wheat. The amount of importation varies from year to year but in 1944, an average year, 500,000 tons of wheat and 200,000 tons of corn were imported.

Many factors have contributed to insufficient food production but among the most important are geographical factors. Mexico has a total area of about 491,000,000 acres, approximately one fourth that of the United States, but only about 12% of this total constitutes potential arable land. Actually only about 7.6% is at present being utilized for farming, of which more than half is periodically fallow. This low percentage of arable land is largely due to the fact that most of Mexican terrain is either too mountainous or too dry to be of use agriculturally. Much of it is often both mountainous and too dry. Rains in many areas can be expected only from June to October while the rest of the year is dry.

From the agricultural and agrarian viewpoint the country comprises a number of well defined natural regions as described by McBride, 1923.[3] These are shown on the map, Fig. 1. The Northern Mesa and the Central Mesa constitute what is known as the great plateau of Mexico. It varies in elevation from about 4,000 feet in the north to an average elevation of around 8,000 feet in the south-central area and comprises about three fourths of the total area of Mexico. This great plateau is bordered on the east, west, and south by mountainous, escarpment areas with elevations up to 18,000 feet. The southern and Chiapas highlands are also very rough and mountainous but somewhat lower in elevation. Along the Gulf is a long comparatively narrow strip of low-land called the Gulf Coastal plains. On the West coast, the mountains practically rise out of the sea except in the north where there is a wider strip of low level arid land called the Sonoran desert and plain. Lower California is much like the Sonoran desert.

The Northern Mesa is a continuation of the basin and plateau country of Arizona, New Mexico, and western Texas. It consists chiefly of vast stretches of nearly level land, covered with mezquite and cactus. Its low annual rainfall of from 5 to 20 inches with a very irregular distribution makes it of little value for agricultural purposes. Because of this aridity the principal use of the land is for grazing, except in an area around Torreon where a small irrigated region known as La Laguna is devoted to the production of wheat and cotton. The Northern Mesa comprises about one half of the total area of Mexico but contains less than one-fifth of the population.

This is in sharp contrast to the region to the south known as the Central Mesa where over half of the people live in an area comprising about 15% of total Mexico. The difference is rainfall. Here the average rainfall between June and October varies from about 20 to 40 inches, which together with its seven or eight extensive flat bottomed valleys has made this area the granary of the nation. The life of the nation has always depended upon its crops of corn, wheat, and beans.

The escarpment areas and highlands to the south are

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[2]Geneticist—Rockefeller Foundation. Acknowledgment is gratefully made to Dr. J. G. Harrar, Field Director for Agriculture, The Rockefeller Foundation, for much of the information incorporated in this report and for his many helpful suggestions in the preparation of the manuscript.

[3]McBRIDE, G. M. Land Systems of Mexico. American Geographical Society. 1923.

primarily made up of small steep-sloped valleys and narrow ridges with little level ground either in valley floors or in interfluvial spaces. On the east and south rainfall is sufficient, but very little of its terrain is adapted to agriculture. Some of the steep slopes are cultivated, with a common rotation of corn 1 or 2 years and brush 5 or 6 years. The small alluvial valley floors at the bottom of the steep slopes are usually endowed with rich deposits of deep black soil and are highly prized and eagerly sought by the agriculturist. Communications, however, are so difficult that most of these valleys are of little importance in the commercial production of foodstuffs.

The western escarpment area is semiarid with many of the interfluvial areas too dry for farming. Characteristics of the western escarpment are the deep-cut barrancas through which flow the few rivers that cross its surface and provide water for irrigation in some of the more level areas of the Sonoran desert for the production of sugarcane, tobacco, coffee, and tropical fruits. One of the largest irrigation projects in the Sonoran desert is in the Yaqui valley which produces considerable commercial quantities of rice, wheat, and flax.

The lowlands on both the east and west coasts are what the Mexicans call "Tierra Caliente". Neither the Indians nor the whites have found the Tierra Caliente a congenial place to live and most of these regions have always been sparsely populated. The west coast is generally too dry and the east coast with the exception of Yucatan too hot, humid, and unhealthy for rapid colonization. Rainfall during the rainy season on the east coast varies from 50 inches in the north to 118 inches in the State of Tabasco. The northern part of the Yucatan Peninsula has no mountains to precipitate moisture from gulf winds and is comparatively dry. This comparative aridity seems to have favored rather than hindered the occupation of the land and for many centuries the region has been densely populated and has been the home of a relatively advanced civilization. The character of the soil, a porous, corraline limestone, together with the scarcity of rainfall, barely makes possible the growing of cereals. The production of corn has been adapted to the climatic conditions and has afforded man a possible, if meager, means of subsistence. A certain amount of wealth, however, has come to this area in recent times through the production of henequen and exportation of sisal fibers.

The foregoing statements suffice to indicate that good agricultural lands in Mexico are extremely limited. Nevertheless, during the last 15 or 20 years the urge has been for greater production by bringing new land into cultivation through the development of irrigation facilities or otherwise, and by increasing production on cropland already cultivated by bringing it

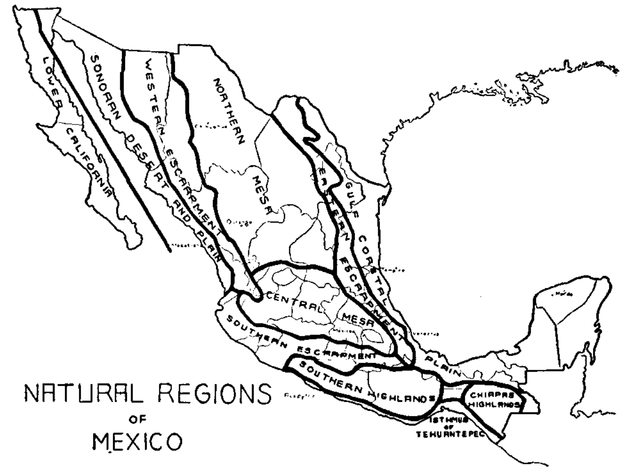

FIG. 1.—Natural regions of Mexico; adapted from G. M. McBride, Land Systems of Mexico, American Geographical Society, 1923.

under irrigation where possible. About 7 out of every 8 pesos of the federal money devoted to agricultural improvement has been spent for this purpose. Mexico is a land-hungry country and a certain amount of expansion is feasible, but this is a slow and costly process. Mexico is also a dry country. Even in the Central Mesa with 15 to 40 inches of rainfall a season, the rains are often so irregular that much could be gained through supplemental irrigation. It has been estimated that 1 out of every 8 hectares of current and potential cropland eventually can be brought under irrigation.

Although some increase in production may be brought about through the opening of new lands and increased irrigation, much more may be accomplished through the application of science to the 8,000,000 hectares of cropland already in production. Only recently have agricultural research and studies on land management and use been applied on an appreciable scale. Agricultural methods are still largely very primitive and much the same as those used by Indians when the Spanish first reached Mexico early in the 16th Century. About 65% of the people are now engaged in agriculture compared to 18% for the United States. A large proportion of these rural inhabitants are living at a very low economic and cultural level. The present and future plight of these people cannot be understood without some knowledge of past and present systems of land tenure.

System of Landholding Changed

After the Conquest the land went from a system of land-holding Indian villages in which each head of family was entitled to a small plot of land to private estates called "haciendas" and chiefly owned by Europeans. In 1910, 1% of the people held 85% of the arable land, 95% of the people owned no land at all but worked at a low wage for the large estate. Haciendas frequently were tremendous, comprising up to 250,000 acres of land.

After the revolution which started in 1910 the land again went back to the Indians. Some of the haciendas were completely destroyed and disintegrated, others managed to hold from 250 to 500 acres for each person in the family. The rest of the land went back into a village landholding system patterned after the systems of the highly organized Indian tribes before the Conquest. The laws of the present agrarian code of Mexico are too detailed to mention here but in general the end result was the ejidal system.

In the ejidal system each village or group of peasants has become entitled to a certain plot of land to be owned in common. Such a group is called an "ejido" and the amount of land each ejido may have generally depends on the number of heads of families, usually about 4 hectares (10 acres) per family head. The land may be worked cooperatively or individually. The legal arrangements are that the land cannot be sold, rented, mortgaged, or worked on shares and if the holder fails to work it for 2 years in succession it may be taken from him. Most ejidos are worked individually.

Thus it is evident that since the revolution two types of farms have evolved; namely, small farms with 5 to 10 acres of land, and larger farms with 25 to 500 acres of cropland. The small farms with 10 acres or less outnumber the larger farms about 25 to 1. There are 2,500,000 small farms and 100,000 larger farms. The 100,000 larger farms represent about 5% of the total number of farms and about 25% of the cropland. These large farms are usually privately owned and operated by the owner or through a manager. They are often progressive and well managed. Many of them can be and are being mechanized.

The 2,500,000 small farms in the ejido system with about 75% of the cropland represent the real problem. Some of the ejidos are making progress but a large proportion of this group are living at about the same general cultural level at which they lived during much of the Colonial Period shortly after the Conquest. A high percentage of the ejidatarios are illiterate. Most of them live in villages, and travel out to their fields early in the morning and return early in the afternoon. In many cases the ejidatarios are living in the same shacks they occupied as peones. Their families have increased in size but production on their small plots of land may have decreased. Methods are primitive and equipment consists usually of a team of oxen and an old Egyptian type wooden plow. This implement is used to prepare seed beds, to plant corn, and as a cultivating tool. Work, other than that which can be done with this wooden plow, is done by hand. The ejidatarios are chiefly concerned with the production of corn, wheat, and beans in sufficient quantities to keep them alive from one season to the next, but with depleted soils, primitive methods, drought, inferior varieties, and lack of means of control of insect pests and diseases their yields are extremely low. Many of them in addition to cultivating their small plots are employed on a part time basis by the larger farms at from 2.50 to 4.00 pesos a day.

FIG. 2.—About 75% of the cropland is divided into small farms of approximately 10 acres each. The farmers are principally Indian. Their methods are primitive. Their equipment consists usually of a team of oxen and an Egyptian type wooden plow which is used to prepare their seed beds, plant their corn, and as a cultivating tool.

The larger farms of commercial farmers of Mexico in most instances are also handicapped by depleted soils, poor crop varieties, and the ravages of plant diseases and insect pests but their production, or return per man hour, is considerably higher. Results of a recent study made by Dr. Herrell DeGraff, Agricultural Economics Department, Cornell University, on remuneration per man-hour for labor on a few ejidos and larger farms are given in Table 1. In the production of wheat under irrigation in the winter months the return per man-hour on the ejido was 62 centavos compared to 2 pesos and 56 centavos on the larger farm or present-day hacienda. In corn the relationship was similar with a return of 86 centavos for each man-hour on the ejido compared to six pesos and 5 centavos on the "hacienda".

Mexico's history of land tenure together with many centuries of continuous corn and other soil-depleting crops on their limited agricultural lands combined with primitive methods, have resulted in one of the

TABLE 1.—*Remuneration per man-hour in ejido compared to hacienda (pesos).*

Crops	Ejido	Hacienda
Wheat (winter)	0.62	2.56
Corn	0.86	6.05

lowest average crop yields in the world. Therefore when Mexico requested assistance from the Rockefeller Foundation in developing its agricultural resources the request was given sympathetic consideration.

Foundation Program Initiated

Although an operating program in agriculture would be a new venture for the Rockefeller Foundation, the fundamental approach to human health and welfare through better nutrition, resulting from the greater production of quality foods, created considerable interest. It suggested the possibility of a real contribution and the establishment of a new pattern for the direct approach to problems in human nutrition.

In 1941 a committee of three distinguished agricultural scientists was commissioned by the Rockefeller Foundation to investigate agricultural conditions in Mexico and prepare a report as to the desirability of establishing a Rockefeller Foundation sponsored program. The committee selected consisted of Dr. E. C. Stakman, chairman, Dr. P. C. Mangelsdorf, and Dr. Richard Bradfield. After spending several months in Mexico, this committee prepared a report urging favorable action with the point of view that the Foundation could render effective service to the cause of human welfare, through basic agricultural studies in Mexico, which might readily be of great significance not only to Mexico but to other Latin American countries as well. The committee recommended that initially the program should concentrate on studies in the fields of (1) soil science, (2) plant breeding, (3) plant protection, and (4) animal husbandry.

Many of the high officials of Mexico realized that the future economic development of their country depended entirely upon greater efficiency of production on the lands already under cultivation. A program which had as its objective the improvement of soil fertility through improved management and conservation methods, better varieties of crop plants, and more adequate control of insect pests and diseases had tremendous appeal; and the Mexican Government requested the help of the Rockefeller Foundation in the initiation of such a program. In 1942 the Rockefeller Foundation accepted this request realizing that it might have far-reaching effects in the promotion of human welfare.

The cooperative agricultural program with the Mexican Government actually began functioning in 1943 with Dr. J. G. Harrar as Director and the original committee of three members retained as advisors. It is organized as the Office of Special Studies of the Department of Agriculture. This office is semi-official in nature and functions as a joint dependency of the Ministry of Agriculture and the Rockefeller Foundation and thus has the freedom necessary to furnish most effectively the assistance requested by the Mexican Government. Both agencies contribute financially to the program and in addition the Government of Mexico has provided land, labor, office and laboratory space, contributions toward constructions, certain items of machinery, fertilizers, etc. The Secretary of Agriculture has also commissioned a total of 69 young Mexican agricultural scientists as trainees in the Office of Special Studies.

The Rockefeller Foundation permanent staff, in addition to the director, consists of four men in plant breeding, two in soils, two in entomology, one in plant pathology, one general botanist and librarian, and one administrative assistant. It was mutually agreed that the program should consist of two phases, namely fundamental research on methods and materials leading to increased production of basic food crops for Mexico; and a training program for selected young Mexican agricultural scientists designed to aid in the development of an ever-increasing body of serious well-trained Mexican agricultural investigators and teachers, who themselves would continuously increase the scope of agricultural research in Mexico. The Foundation staff together with its young commissioned personnel operate as a unit and maintain close cooperative relationships with various other agricultural agencies of the Mexican Government.

The main research station of the joint project is located at Chapingo on a 260 acre tract of land adjoining the National School of Agriculture about 25 miles northeast of Mexico City. On this station construction of a field laboratory and a series of four greenhouses was recently completed. The station is adequately provided with irrigation facilities and general farm equipment. It is comparable in equipment, facilities, and work being done to the leading stations elsewhere.

The Foundation program for obvious reasons has been chiefly concentrated in the area described earlier as the Central Mesa. It covers an area about 700 miles long and from 250 to 300 miles wide, and varies in elevation from 5,000 to 8,500 feet. The main station is located at about 7,500 feet elevation. To cover the area adequately in plant breeding and other fields, other stations have become necessary. Although the soil conditions may vary considerably from one valley to the next in the Central Mesa the climate largely depends on elevation. For the purposes of plant breeding the Central Mesa has been divided roughly into three zones on the basis of elevation: Zone 1 includes elevations of 7,000 to 8,000 feet; Zone 2–6,000 to 7,000 feet; and Zone 3–5,000 to 6,000 feet. The work for Zone 1 has been and can be readily concentrated at the main station. The basic breeding and testing work for the other two zones has been conducted in cooperation with interested farmers and in cooperation with other

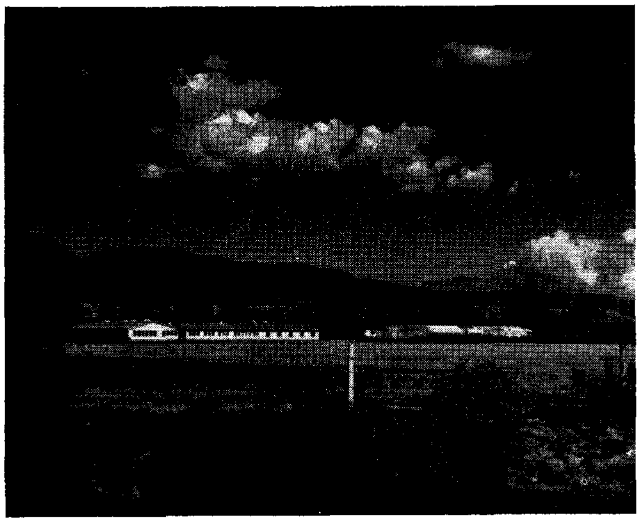

FIG. 3.—The main research station of the Rockefeller Foundation is located at Chapingo on a 260-acre tract of land adjoining the national School of Agriculture about 25 miles northeast of Mexico City. Construction of a field laboratory and a series of four greenhouses was recently completed. This station is comparable in equipment, facilities, and work being done to the leading stations elsewhere.

agencies of the Mexican Government insofar as their facilities permitted. This year a second experimental station under the auspices of the Office of Special Studies was established in Zone 3.

Most of the work of the various divisions such as plant breeding, disease and pest control, and soil management and fertility studies is focused on the increased production of the three crops, corn, wheat, and beans. The various phases are all mutually interdependent and proceed in parallel fashion. Each contributes to the others and the results obtained in any division are necessarily due to the combined efforts of the members of all divisions. All members of the staff work together as a team with a common objective—that is, increased production of corn, wheat, and beans.

Corn Program Emphasized

Since corn is the main food crop it has received considerable attention. Most of the native varieties are low in yield capacity. Selection for many centuries, both natural and artificial, has been for those characters that tended to make varieties better adapted to the extremely adverse conditions such as drought, frosts, and depleted soil fertility rather than for yield capacity. For many centuries low yields have meant hunger for the Indian tribes but a crop failure might mean starvation. Since it has been impossible to store corn from one year to the next because of excessive weevil damage, a bumper crop in any one year in ancient times did not have the appeal that it does today when more corn may not only mean food but pesos. The tendency has been to develop varieties that were more sure to yield something from year to year rather than high one year, low the next, and even nothing when conditions were more extreme. Many varieties on the high plateau in addition to their low yield capacity are very susceptible to smut, root rots, ear rots, and a comparatively new virus disease which Dr. L. O. Kunkel has described as stunt. A combination of these diseases causes considerable loss every year.

Varietal improvement for each of the three zones mentioned earlier was started more or less simultaneously in 1944. The objective has been gradual improvement which could be obtained rapidly and be passed on to the farmers immediately. Samples of corn have been collected from all over Mexico and have been tested in the Central Mesa. As a matter of fact, the Mexican Corn Collection is one of the largest and most varied collections of corn in existence anywhere. This has not only provided abundant breeding material but has also provided material for fundamental studies of corn types and races leading to further classification of phylogenetic affinities. In most cases the best open-pollinated varieties were first isolated, increased, and distributed to the farmers. Some of these varieties found in isolated areas were substantially superior to the types commonly grown in the different valleys of Mexico and farmers readily accepted them as replacement for their old varieties.

Further improvements have been largely based on the utilization of first generation inbred lines in the formation of synthetic varieties and hybrids. The objective has been to make up hybrids in such a way that in advanced generation they would also make good synthetics. In this way the more progressive farmers who understand the use of hybrid corn can take advantage of the extra yield of first generation crosses and those that do not understand or for other reasons cannot make use of first generation seed will have available advanced generation seed or synthetics substantially superior to the native varieties. In this way the farmers make their own synthetic varieties from outstanding raw material provided by the plant breeder. New varieties are more easily introduced as hybrids because of their greater superiority in yield, uniformity, and general eye appeal in demonstration plots. This is a very important consideration in a country where the same variety has been passed on from generation to generation for centuries with only gradual change.

What has been accomplished in each of the three zones is illustrated in Table 2.

From the introduction of selected open-pollinated varieties a gain of 15 to 20% was generally obtained over the open-pollinated varieties commonly grown. Another 10% to 26% has been gained by the formation and introduction of synthetics, and through the formation of hybrids utilizing one-generation selfed

TABLE 2.—*Comparative improvements obtained in the various zones by different methods of breeding, with selected varieties taken as 100%.*

Method of breeding	Zone 1		Zone 2	Zone 3	Zone 4–5
	Early	Late			
Common open pollinated varieties	80–85	80	75–85	50–80	85
Selected varieties	100	100	100	100	100
Synthetics	120	110	126	115	—
S_1 line hybrids	148	127	141	129	—
Advanced line hybrids	—	—	—	133	—

lines, yields have been brought up to 27% to 48% more than the selected open-pollinated varieties used as checks. It is of interest to note that the highest yielding hybrid yet obtained is one made for Zone 3 with advanced inbred lines.

In addition to yield capacity, the improved varieties show considerably more resistance to ear rots, root rots, rusts, and smuts than the native varieties. This has been largely due to the very close cooperation between the breeders and pathologists in the evaluation of the basic breeding material for resistance to the respective diseases. At the present time both the plant breeders and the pathologists are greatly concerned with the virus disease known as stunt, which is transmitted by leafhoppers. So far only certain tropical corns have indicated any degree of resistance.

The corn improvement program has received excellent and enthusiastic cooperation on the part of the Mexican Government. In 1947 the present President of Mexico, Lic. Miguel Aleman, by special decree created a Corn Commission for the purpose of increasing, demonstrating, and distributing seed of the improved varieties of corn. Through the close cooperation of this

FIG. 4.—Corn is the main food crop. Native varieties are low in yield capacity. Work in varietal improvement was started in 1944. Approximately 10% of all corn in the Central Mesa is now planted with new improved varieties yielding from 10 to 30% higher than the best of the old varieties. Even more significant and far reaching is the training received by the eager young competent Mexican scientists in basic corn breeding methods.

agency with the Office of Special Studies, approximately 10% of all corn in the Central Mesa is now planted with the new improved varieties obtained during the past 5 years.

Hybrid corn was introduced in the three areas simultaneously. In 1948 for the first time in the history of Mexico, 1,000 hectares or 2,500 acres were planted in detasselling blocks for the production of hybrid seed. Total seed acreage including open-pollinated varieties for that year was about 5,000 acres. This year another 2,500 acres were planted for hybrid seed production, about half of which is devoted to new hybrids just released. When new and better hybrids become available they immediately replace the previous ones on the production list. This rapid progress has been made possible through the production of two crops a year in both the breeding nurseries and foundation seed increase fields.

The success in the winter breeding fields has been largely due to the close cooperation of the entomologists, under the direction of J. J. McKelvey, in working out control measures for the many insects that made work extremely difficult and often impossible. The first year in large scale winter production about 70% of the stand was destroyed by the army worm when the plants were small. These worms are now readily being controlled by two or three applications of 3% to 5% DDT when the plants are very young. Thrips have also given considerable trouble but fortunately the same treatment that controls the army worm also controls thrips. During the last two years about tasselling time an extreme infestation of red spider and aphids appeared. The aphids seriously interfered with pollinations and red spider greatly reduced the production. Early applications of DDT probably destroyed the predators of these latter insects and allowed them to build up.

During the rainy season insects have not been a serious problem in corn production. However, in certain double cross seed production fields pollen on the male rows was eaten or completely destroyed by millions of rose chafers with the drastic result that no grain was set on the female rows.

Wheat Growing Extends to Rainy Season

Wheat breeding under the direction of N. E. Borlaug has gone along simultaneously with corn breeding and significant advances have been made. The primary objective in the wheat breeding work has been to obtain stem and leaf rust resistance in combination with time of maturity needed to fit the various wheat growing areas of Mexico. As in corn as soon as something was developed that had definite superiority over native varieties it was increased and released for distribution to the farmers.

Although the Central Mesa is one of the important wheat-growing areas, there are two irrigated regions in the north, very important from the standpoint of total wheat production; namely El Yaqui in the Sonoran desert and La Laguna in the Northern Mesa. These commercial areas of production are completely mechanized. Rust resistant varieties obtained by direct selection from Dr. McFadden's material in Texas, from other introductions, and from crosses between native and rust-resistant varieties from the States are now available for the three important wheat areas of Mexico. These varieties in bad rust years have made the difference between good yields and complete failures. Furthermore, it is now possible with these resistant varieties to grow wheat during the rainy season in the Central Mesa. Before, wheat was limited to the dry season and to those farmers who had irrigation facilities. In the north, production is limited to the winter months because of high summer temperatures but the fact that at the higher elevations wheat can be grown during the rainy season can have far-reaching effects. It means that with these new rust resistant varieties in conjunction with soil improvement and better cultural methods, Mexico can become self-sufficient in both corn and wheat.

For increasing wheat and improved seeds of crops other than corn, the Secretary of Agriculture created an organization called the Commission for the Increase and Distribution of Improved Seeds. This Commission so far has operated primarily with wheat in cooperation with the Office of Special Studies and has done an excellent job. The seed is grown under contract with the farmer and at harvest, cleaned, treated, and sacked with a series of portable seed cleaning machines. It is then stored in some central location for the next season. By growing it in both summer and winter it has been possible to increase seed wheat very rapidly. For the coming winter plantings 7,000 tons of good seed of the new varieties released will be available for commercial planting.

Bean Disease a Problem

The bean improvement program has lagged behind that of corn and wheat because the bean problem has not been as acute as that for the other two crops. In general Mexico has been self-sufficient in beans and usually exports some black beans to Cuba.

Beans, like corn, are native to Mexico and a tremendous number of different varieties and genotypes exist. The program has been concentrated on the main station at Chapingo. The primary objective has been to isolate superior strains by straight individual plant selection from mixed populations. Three varieties obtained in this way have been released for commercial production in the highlands between 7,000 and 8,000 feet elevation. Sufficient seed to plant 250 acres was released to the federal seed commission for increase in the spring of 1949.

The primary problems on beans have been with diseases and insects. Rust and anthracnose are the two most destructive diseases. For the present the new varieties released are resistant to rust but not to anthracnose. The plant pathologists are studying the race situation in these two diseases as a future aid to the breeding program.

Insects probably cause greater loss from year to year than diseases. Most of the beans are grown associated with corn, which makes insect control through spraying and dusting more difficult. In breeding, emphasis has been on the nonclimbing types that might be grown alone and be more readily accessible for insect control. As a result of the close cooperation between specialists in entomology and plant breeders certain strains resistant to the Apion pod weevil have been isolated. This insect destroys the grains in the pod and causes considerable damage throughout the Central Mesa. The entomologists have found that it can be controlled by spraying or dusting with DDT when the pods are just beginning to form. Other insects that cause considerable damage are commonly known as the Mexican bean beetle, leafhoppers, and white fly. Best methods of control of these insects are being investigated and as soon as methods become known they are demonstrated to the farmers.

Recognize Soil Deficiencies

The introduction of new, improved varieties and the control of insect pests and diseases will go a long way toward the improvement of agriculture in Mexico but its efficiency is greatly reduced without improvement of the depleted soils and primitive tillage methods. Extensive studies in soil management and fertilizer use have been under way, under the direction of J. B. Pitner. With respect to the common mineral elements, nitrogen is generally lacking in all soils, phosphorus is generally lacking in forest soils which represent the more humid regions, and in other soils maximum yields usually cannot be obtained in years of good rainfall without the application of a certain amount of phosphorous. Potash generally has been found to be sufficient except in certain small specific areas. In spite of the poor physical condition of the soil fertilizer responses have been spectacular. An application of 500 pounds of 8–8–0 often doubles the yields and in some areas in the State of Jalisco increases of several hundred per cent have resulted. Therefore, fertilizer often makes the difference between an excellent crop and a very poor one. Over the Central Mesa as a whole, because of irregular rainfall distribution and poor tillage methods, low applications of fertilizers, that is 250

FIG. 5.—Wheat breeding has gone along simultaneously with corn breeding. The primary objective has been to obtain stem and leaf rust resistance in combination with time of maturity needed for the different wheat growing areas. New rust resistant varieties have made the difference between good yields and complete failures in bad rust years. Seven thousand tons of seed of new rust resistant varieties are available for the 1949–50 winter planting. As in corn, training of young Mexican scientists in basic principles of wheat breeding has been one of the important phases.

pounds of 8–8–0 per acre, have been at present more efficient than higher applications. Often small amounts of nitrogen alone will do wonders. In the use of small amounts of fertilizers it is doubly important that they be applied in such a way as to give their maximum efficiency. Research on methods of application are in progress.

The two government agencies in charge of the increase and distribution of corn and wheat have used extensively fertilizers recommended by the Office of Special Studies and have done more toward the demonstration of the value of fertilizer in combination with good seed than any other group in Mexico. A yield of 125 bushels per acre was obtained on a measured plot of 2.5 acres with one of the improved corn varieties in one of the demonstration and increase fields in the Valley of Mexico at 7,500 feet elevation. Some of the well fertilized double cross production fields in areas where rainfall was well distributed yielded about 80 bushels per acre. In wheat, yields of 50 bushels per acre on some of the well fertilized increase fields have not been too uncommon. In some of the increase fields of beans where insects were not a factor, yields of 30 bushels per acre were obtained. These yields are the exception rather than the rule at present but do illustrate the possibilities with good farming methods.

Legumes Tested

Along with the fertilizer work, extensive studies are being made with certain legumes in rotation and interplanting with wheat or corn. Commercial nitrogen is not only very expensive at the present time, but difficult to get. In many areas, legumes for green manures can be established without fertilization but in others a small amount of nitrogen and phosphorus is a great help in getting them off to a good start.

As a green manure crop, Hubam sweet clover has shown considerable promise in the Mesa Central. In areas with higher rainfall, it has given excellent results interplanted in corn at the last cultivation. At the end of the rainy season when the corn matures, the sweet clover makes a rapid growth on the moisture remaining from the last rains and is usually ready to turn under in January during the dry season. This system of soil improvement offers considerable opportunity for the small farmer or ejidatario who feels he must plant corn each year on his small plot to provide for his family. By interplanting a legume with his corn, it is possible for him to increase soil productivity, provide feed for his livestock, and still produce the necessary corn crop.

Hubam sweet clover has also been planted in wheat with good results especially in the winter time under irrigation. In summer wheat during the rainy season, it is more difficult to get stands because of weeds. Weeds in summer wheat usually need to be controlled with 2,4–D and this also kills the young legume plants.

Double Man-hour Returns

That the improved seed and fertilizer program is already having its effect on the agricultural economy of

FIG. 6.—Field days are held at opportune intervals on the various experimental stations and fields of the Rockefeller Foundation for the purpose of promoting the use of improved seed, fertilizers, green manure crops, and disease and insect control. At these field days both the large and small farmer have shown intense interest in the work underway and the results being obtained. In extending the results of basic research to the farmer, the two seed increase and distribution agencies created by the Mexican Government have been especially effective.

TABLE 3.—*Remuneration per man-hour (pesos) in ejido using improved seed and fertilizer.*

Crop	Old methods	Improved seed and fertilizer
Corn	0.86	1.69

Mexico is reflected in the recent studies of Dr. Degraff. The remuneration per man-hour in ejidos using improved seed and fertilizer is practically double that of those continuing with their old methods as shown in Table 3.

What has been done with the improved rust resistant wheat varieties plus fertilizers on the large farms is even more striking. By growing wheat during the rainy season, made possible by rust resistant varieties, instead of under irrigation in the winter months, the remuneration per man-hour is almost 10 times as great as shown in Table 4. The difference is largely due to the high cost of water and the extra man-power needed for irrigating the poorly leveled land.

With respect to extension work, most of it so far has been done through the two seed increase and distribution agencies. Much of the personnel in these two agencies has been trained by the Office of Special Studies and they not only have distributed seeds, but have promoted the use of fertilizer, Hubam sweet clover, and good cultural practices wherever possible. This has been supplemented through field days on the various experimental stations at opportune intervals. At these field days, both the large and small farmers have shown intense interest in the work under way and the results being obtained.

Simultaneously with the research, the Rockefeller Foundation group has carried on an intensive training program. The young men who have been commissioned to the program by the Mexican Government have worked along with the various specialists in their research activities. By participating directly in the field and laboratory phases of the program, they have an opportunity to gain considerable practical experience and technical information in their special fields of interest. Every Saturday is set aside for library work and special seminars. Many of them have used the results of their researches for the preparation of theses in partial fulfillment of requirements of professional degrees in their national school of agriculture. As they advance in their training and interest, they are given greater responsibilities in the program.

TABLE 4.—*Remuneration per man-hour (pesos) with winter versus improved summer wheat on large farms.*

Rust susceptible variety Winter	Rust resistant variety Summer
2.56	24.97

Those who have demonstrated an aptitude for research and have learned the English language, are given consideration for Rockefeller Foundation Scholarships in the United States for a minimum period of one year. To date, 28 scholarships of this type have been awarded to young Mexican agricultural scientists. Of these scholars, 18 have returned to Mexico and are occupying responsible positions in agricultural research and education. Some have gone into extension activities, some into teaching, and others into research. As stated before, the Foundation program has been concentrated on the Central Mesa. Requests have been received from groups outside of this area to extend activities more directly to them. This extension will have to come largely through Foundation trainees and by direct support from the individual states or federal government or both.

Training has not only been limited to Mexicans. To date six scholars from the United States, ten from Colombia, three from Guatemala, one from Honduras and one from Bolivia have been received for periods of 6 months or more by arrangements with the Rockefeller Foundation.

The training phase of the Mexican agricultural program is perhaps the most significant and far-reaching in its activities. Those that have been associated with the program have seen what agricultural research can do. They have gained confidence, vision, and enthusiasm for the scientific method. Those that have gone out into other areas with other government agencies or into teaching, still consider themselves as part of the Office of Special Studies and whenever possible, return to their former teachers for advice and guidance in their new jobs. This growing body of eager young competent scientists offers great hope for future agricultural progress in Mexico, and the association of young scientists from several different American countries must necessarily have a beneficial effect on international agricultural problems.

In conclusion, I wish to point out that Mexico at present is a country in which there is very great interest in agricultural advancement through agricultural research and its application. This, in part, has been due to the rapid practical results obtained through the Rockefeller Foundation Agricultural Program initiated 6 years ago. Actually the greatest benefits are yet to come but the Mexican Government and officers and trustees of the Rockefeller Foundation believe it to be a successful collaboration thus far. There is every reason to believe that from now on the work each year will build on previous accomplishment and the benefits to the nation will accrue like compound interest.